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Indian Science Congress.



Proceedings
of the
Sixteenth .
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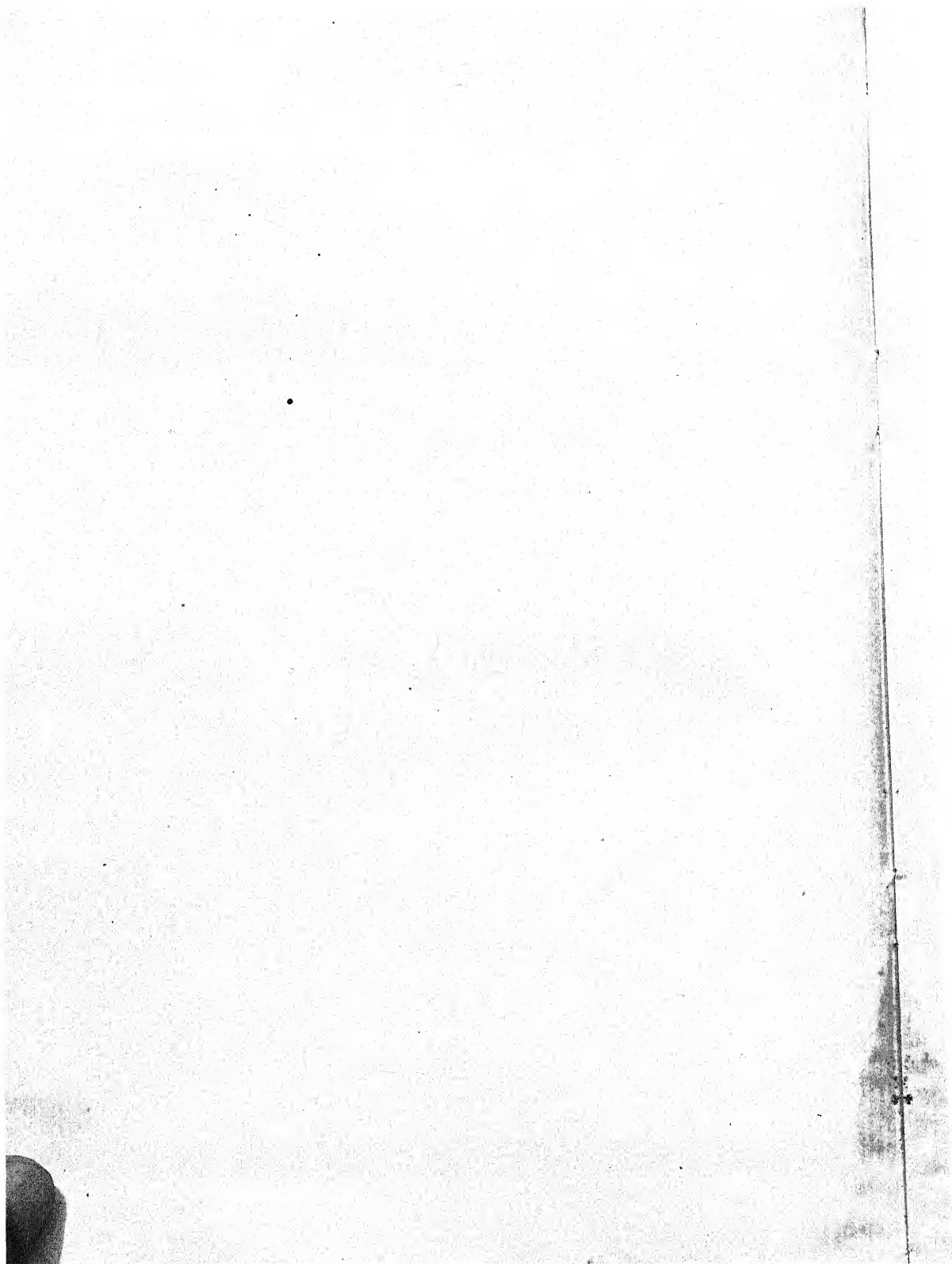
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The sixteenth meeting of the Indian Science Congress was held in Madras from January 2nd to the 7th, 1929. His Excellency the Governor of Madras welcomed the delegates in a short speech after which the President, Prof. C. V. Raman, delivered his address.

The Sectional Presidential Addresses were delivered as follows :—

Thursday, January 3rd, 10 A.M., Agriculture; 11 A.M., Psychology; 12 noon, Mathematics and Physics.

Friday, January 4th, 10 A.M., Botany; 11 A.M., Chemistry; 12 noon, Geology.

Saturday, January 5th, 10 A.M., Medical and Veterinary Research; 11 A.M., Anthropology; 12 noon, Zoology.

The following general discussions were held :—

Friday, January 4th, on "Rural Education." President Mrs. G. L. C. Howard.

Saturday, January 5th, on "Mathematics and Life." President Prof. M. V. Gopalaswami, B.Sc., Ph.D.

The following functions were arranged in connection with the Congress :—

January 3rd, 2 P.M. to 4 P.M. Excursions to the following places :—

1. Messrs. Massey and Co. Engineering Works.
2. X-Ray Institute and General Hospital.
3. The Victoria Technical Institute.
4. The Veterinary College where Dr. Krishnamurthi Aiyar gave a Lantern Demonstration on "Anthrax in Man and Animals."

4-45 P.M. Garden Party at Government House.

January 4th, 2 P.M. to 4 P.M. Excursions to the following places :—

1. Madras Port Trust and the Light House.
2. The Wireless Station and the General Post Office.
3. The Government Ophthalmic Hospital.
4. The Aquarium and Presidency College (Natural Science).
5. The Museum.

4-45 P.M. Garden Party given by the Local Committee in the grounds of the South Indian Athletic Association, People's Park.

January 5th, 2 P.M. to 4 P.M. Excursions to the following places :—

1. Peramber Railway Workshops.
2. Ennore.
3. The Buckingham and Carnatic Mills.
4. Kilpauk Municipal Water Works and Red Hills Reservoir.

January 6th, whole-day excursions to the following places :—

1. Canjeevaram.
2. Mahabalipuram.
3. Chidambaram.
4. Coimbatore.

January 7th.

1-15 P.M. Garden Party to (Past and Present) officials of the Indian Science Congress at Government House.

2-4 P.M. Excursions to the following places :—

1. The King Institute of Preventive Medicine, Guindy.
2. The Madras Engineering College, Guindy.
3. The Government Hospital for Women and Children.
4. Presidency College (Physics, Chemistry, Botany and Zoology Sections).
5. The Government Medical Stores.

8-15 P.M. Congress Dinner (Moore Pavilion, People's Park).

The Popular Lecture were delivered as follows.

January 3rd, 6-30 P.M., "Chemistry as the Friend of Man" by Dr. M. O. Forster, D.Sc., F.R.S. (Victoria Public Hall).

January 4th, 6-30 P.M., "Some Aspects of Indian Vegetation" by Prof. S. P. Agharkar, M.A., Ph.D., (Victoria Public Hall).

January 7th, 6-30 P.M., "The Structure of Matter" by Prof. C. V. Raman, M.A., D.Sc., F.R.S. (Victoria Public Hall).

The Council met on the 3rd January.

The Executive Committee met on the 3rd January.

The General Committee met on the 4th January.

Opening Proceedings.

The sixteenth session of the Indian Science Congress was opened on Wednesday evening, the 2nd January, 1929, at 6 P.M., by His Excellency Viscount Goschen, Governor of Madras, the Patron of the Congress, at the Banqueting Hall, Government House, Mount Road, in the presence of a large gathering of delegates and visitors. A large number of ladies were also present.

In declaring the Congress open, H.E. the Governor spoke as follows:—

“LADIES AND GENTLEMEN,

It is a very great pleasure to me this afternoon to have this opportunity of welcoming, on behalf of the people of Madras, the members of the Indian Science Congress here in our city, and I am delighted, as I am sure they will be, to see here such a large gathering. This is, I believe, the sixteenth meeting of the Congress; twice previously predecessors of mine, Lord Willingdon and the late Lord Pentland, welcomed the members of this Congress. It is interesting for us to remember that, when the Congress was held fourteen years ago, Professor Raman, our President this year, was then the Chairman of the Section of Physics. It is a special pleasure to me to know that in a very few moments I am going to hear his presidential address because it was only a few weeks ago that I heard him give an address on another occasion in another part of this Presidency. That occasion has only whetted my appetite for more. I do not want to plunge into the deep waters of scientific research; perhaps, I may say that I have dabbled on the edge of these waters because I was the Chairman for some years of the Medical Research Council at home, a position which excited my interest in scientific research, and, I can assure you, has aroused my keen enthusiasm for those who are taking part in that work. Speaking as a layman, which I feel requires some courage to-day, I think I may rightly say that laymen have not perhaps taken the interest they ought to in scientific research and scientific questions; but I am going to be brave enough to make one complaint against scientists and that is that they are too modest, too unassuming, and too retiring, so that the public have not always realized the worth of their work. The interest of the public is often aroused when some epoch-making discovery has been made and brought to their notice. I do not think that on such occasions they realize what it really

means. They do not even understand that it is perhaps not only those who announce that discovery who have been working but that a generation and perhaps even two generations before some people have been carrying on spade work in the direction. Quietly, unknown to the public, persons have been working hard and zealously to bring about these great discoveries which have proved of great benefit to us. I think, perhaps, that ubiquitous gentleman, the man in the street, is apt to think that scientific work is a hobby of professors which is carried on in laboratories in their own interest, but I do think that in the last few years there has been a closer relationship between the public and the scientists. They understand what discoveries in medical research have done and are doing both in the prevention and in the curing of diseases. They also understand what research in nutrition is doing for the public, for men themselves, for their families and also for their beasts; and to-day, children discuss vitamins amongst themselves. But, last of all, there is that most conservative class of all, the agriculturist. He now understands the benefits which scientific work is conferring upon him, and, I believe that the enquiries of the recent Agricultural Commission in India have done a very great deal indeed to rouse his interest in this subject, an interest which we all hope will be maintained. Therefore, gentlemen, it is because I realize that not only is a Congress of this character of material help to the members who take part in it, in that they have an opportunity of conferring together and exchanging views, but because I believe that meetings of this kind are of immense value in stimulating the interest of laymen, that I wish this Congress a most successful time during its visit to Madras where, I hope, the members who come from various parts of India will find themselves both happy and comfortable."

After the opening of the Congress the President delivered his Presidential Address.

Prof. S. P. Agharkar proposed a hearty vote of thanks to His Excellency for having opened the Congress, which was carried by acclamation. The gathering then dispersed.

Presidential Address.

Congress President :—PROF. C. V. RAMAN, M.A., D.Sc.,
F.R.S., F.A.S.B.

YOUR EXCELLENCY, LADIES AND GENTLEMEN,

It is the privilege of a physicist to concern himself with what may be regarded as the fundamental entities of the material universe we live in. His theories and experiments are directed towards obtaining a clearer understanding of the nature of those entities and of their relationships with each other. His results if expressed in plain language should be intelligible not only to those who profess other branches of science, but to all who take an interest in the varied phenomena of Nature. The work of the physicist has the closest possible bearing on the interpretation of facts observed in other fields of scientific knowledge. No apology is therefore needed for my decision to devote this address to an exposition of the nature and significance of a new phenomenon recently discovered in my laboratory at Calcutta which has a bearing on the fundamental problems of physics and chemistry.

Every one of us is or should be interested in the nature of that phenomenon which we call *light* and which is a species of the genus *radiation*. Light is emitted by matter under suitable conditions of excitation. We heat an atom or excite it by electric discharge. It becomes luminous and gives off radiation. What is radiation? On this point, the physicists of the nineteenth century had come to the very definite conclusion, based on evidence which it seemed impossible could ever be shaken, that light is a kind of wave-motion travelling through space, and of the same physical nature as the electromagnetic waves discovered by Hertz and now so familiar to all as the waves of wireless telegraphy and telephony. Remarkably enough, however, the present century has witnessed a re-opening of the question. I will not pause here to trace in detail the history of the development of what is known to-day as the quantum theory of radiation. It is associated with the names of three great living physicists, namely, Planck, Einstein, and Niels Bohr. It will suffice for my purpose to indicate the very definite and intelligible form it received in Bohr's well-known theory of spectra. According to Bohr, the emission of light from an atom is not a single process but takes place in two distinct stages. The first stage is the energizing of the atom, in other words, its passing over from a normal or non-luminous condition into a new state of higher energy content. The second stage is the return of the atom to a condition

of lower energy accompanied by the emission of light. Bohr found it necessary, in order to interpret the facts of spectroscopy, to assume that the different states of the atom are sharply differentiated from each other in their energy content. The atom therefore takes up energy or gives up energy as the case may be, in passing from one state to another, in discrete bundles or quanta. Radiation is thus absorbed or emitted by the atom in discrete bundles of energy. It follows naturally that while travelling through space, light also remains as discrete bundles or quanta of radiation. A distinctly unitary character is thus indicated for radiation.

Further powerful support for a corpuscular idea of radiation came to hand a few years ago when Prof. A. H. Compton, now of Chicago University, discovered a remarkable phenomenon which is now known by his name as the Compton Effect, and for which he received the Nobel Prize in Physics a year ago. Briefly, what he found was this: When X-rays fall upon matter and the scattered rays are analysed by an X-ray spectroscope, the lines in the X-ray spectrum are found to be doubled. Prof. Compton gave a very simple and remarkable explanation of this fact. He regarded the incident X-rays as consisting of corpuscles which moved with the velocity of light and on hitting an electron in the scattering material dislodged it and were themselves deviated from their straight path. It is obvious that in such a process the deviated corpuscle would lose part of its energy, this being taken up by the recoiling electron. Prof. Compton's explanation of his effect is supported by the fact that the recoil of the electron is actually observed in experiment. A change in energy of the quantum is equivalent to a change in the frequency of scattered radiation, which therefore appears in the X-ray spectrum as a line in a shifted position. Measurements of the change of wavelength and of the velocity of the recoil-electron appeared strongly to support Prof. Compton's theory, and the latter has therefore gained general acceptance.

We appear thus to have reached the astonishing position that two distinct theories of light both claim our acceptance. In other words, light consists of waves expanding spherically outwards from a luminous atom into ever-increasing volumes of space, and it also consists of a corpuscle shot off in some one specific direction from the luminous atom and therefore moving along a straight line to infinity. I have often seen it suggested that there might be no real conflict between these two widely different points of view, if we regard the light corpuscle statistically. In other words, if we had a sufficiently large number of atoms giving out corpuscles, the two pictures of radiation may be statistically equivalent. So indeed they would be, if a corpuscle emitted from one atom and a corpuscle emitted from another could be regarded as equivalent. But such a conception would be totally repugnant to wave-principles. For, when we

consider a luminous gas, the waves emitted by the different atoms in it would not be equivalent unless all the atoms were at the same place and emitting light-waves in identical phase. It is obviously difficult to accept the latter proposition, and in fact we may be fairly certain that it is untrue. The particular suggestion here made for securing a statistical equivalence of the wave and quantum theories of radiation seems therefore untenable. My own feeling is that it is impossible to accept the wave and quantum theories of radiation as simultaneously true if Compton's idea of a localised quantum is a correct and universal description of the process of radiation from atoms. In order to explain the familiar facts of optical interference and diffraction, we are compelled to assume that the light emitted by a luminous atom spreads out spherically with identical velocity and phase in all directions. Theoretically it is possible to analyse a spherical wave into a set of plane directed waves passing simultaneously through the centre of the sphere in all directions, *provided they are all in identical phases at the centre*. We may, of course, regard a plane wave as equivalent to a directed quantum in the sense of Compton, but as a single atom can only radiate one quantum at a time, it is impossible to explain interference if we assume the emission to consist generally of directed quanta. In Compton's own experiment, we are dealing with the secondary radiation from an atom illuminated by X-rays of wave-length much shorter than the diameter of the atom. This is a very different problem from that of an atom radiating spontaneously in all directions. In a paper appearing in the Indian Journal of Physics, I have discussed the case of Compton from what I believe to be rather a novel point of view, and shown that so far from the Compton Effect being opposed to the classical wave-principles, the latter actually indicate the existence of such an effect, and quantitatively predict its observed characters. On the view developed in my paper, Compton's experiment is not a disproof of the spreading wave-theory. We do not regard the beam of radiation thrown out in a straight line by a light-house and travelling for miles without appreciable spreading, as a contradiction of wave-principles, but explain it as an effect produced by the lenses and mirrors of the light-house. In an analogous way, I utilise the relation between the wave-length of the radiation and the size of the atom to explain Compton's results. The investigation shows that the classical and quantum theories of radiation are indeed statistically equivalent, but this equivalence is secured by the properties of the atom, and not by filling space with localised quanta. I will go so far as to say that in my view, it is entirely futile to regard the light-quantum as a particle having any specifiable shape, size or position.

This theoretical paper on the Compton Effect was worked

out during a holiday at Waltair in October, 1927. Apart from any little intellectual satisfaction which its writing may have given me, its chief interest is that it prepared the ground for the experimental work of the following months which I shall now mention.

Eight years ago, we commenced at Calcutta a series of experimental studies on the scattering of light in transparent media of all kinds. These studies were largely inspired by a desire to understand and explain fully such natural optical phenomena as the light of the sky, the dark blue colour of the deep sea and the delicate opalescence of ice in glaciers. It soon became evident that the laboratory studies intended in the first place to reproduce these natural phenomena on a small scale would carry us some way towards a solution of such fundamental problems of physics as the constitution and structure of molecules, their number, arrangement and thermal movements in gaseous, liquid and solid media, and the nature of radiation itself. I will not fatigue you by reciting the numerous experimental and theoretical researches carried out by us on these subjects. Associated with me during these eight years were a great many young physicists from all parts of India who received their research training in my laboratory. Amongst them, I would specially mention the names of Dr. K. R. Ramanathan and of Mr. K. S. Krishnan, both by reason of their conspicuous originality in research and in view of the importance of their personal contributions to the development of the subject now under discussion. To them, and to my numerous other collaborators from Bengal and Madras and Northern India, I owe a debt of gratitude.

At a very early stage in our investigations, we came across a new and entirely unexpected phenomenon. As early as 1923, it was noticed when sunlight filtered through a violet glass passes through certain liquids and solids, *e.g.*, water or ice, the scattered rays emerging from the track of the incident beam through the substance contained certain rays not present in the incident beam. The observations were made with colour filters. A green glass was used which cut off all light if placed between the violet filter and the substance. On transferring the glass to a place between the substance and the observer's eye, the track continued to be visible though feebly. This is a clear proof of a real transformation of light from a violet into a green ray. The most careful chemical purification of the substance failed to eliminate the phenomenon. Subsequent investigations showed the same effect in a considerable number of liquids and solids, and we even attempted a spectroscopic investigation of it.

Though, from time to time, we returned to the study of this new phenomenon and published accounts of it, its real significance as a twin brother to the Compton Effect first became clear to me at the end of 1927 when I was preoccupied with the

theory of the subject. I regarded the ejection of the electron in the Compton Effect as essentially a fluctuation of the atom of the same kind as would be induced by heating the atom to a sufficiently high temperature, and the so-called directed quantum of Compton as merely an unsymmetrical emission of radiation from the atom which occurs at the same time as the fluctuation in its electrical state. The conception of fluctuations is a very familiar one in optical and kinetic theory, and in fact all our experimental results in the field of light-scattering had been interpreted with its aid. There was, therefore, every reason to expect that radiations of altered wavelength corresponding to fluctuations in the state of the scattering molecules should be observed also in the case of ordinary light.

The idea was energetically taken up and the experiments showed it to be completely correct. It became clear that we had here a new radiation effect far more general and universal in its character than the Compton Effect, and of which the latter could be regarded as a special case. The ejection of an electron is a very violent type of fluctuation. There are numerous other comparatively mild types of fluctuation possible in the electrical state of atoms and molecules. Such fluctuations correspond to relatively small changes in the energy-level of the atomic system in the sense of Bohr. If a change of energy-level is produced by the incident radiation and is simultaneous with it, the quantum of radiation emitted under these conditions may be greater or smaller as the case may be than the quantum of incident radiation. We may represent this change as a chemical reversible reaction.

MOLECULE + RADIATION \rightleftharpoons MOLECULE + RADIATION
(normal state) (high frequency) (excited state) (low frequency)

If the reaction proceeds in the direction of the upper arrow, we have a diminution in frequency of the radiation, and if in the direction of the lower arrow, we have an increase of frequency. The relative importance of the two types of reaction would obviously be determined by the law of mass-action, that is to say, upon the populations of the normal and excited states of the molecules present in the irradiated substance. In ordinary cases, the presence of excited states is determined by temperature. Other causes of excitation of molecules if present must also be taken into account.

Since atomic and molecular systems have many possible energy-levels as shown by the facts of spectroscopy, we see in the foregoing chemical equation the possibility of observing a great many new lines in the spectrum of the scattered radiation.

The most convenient way of studying the effect is by using the intense monochromatic radiation of the mercury arc and to condense its light into the substance, or better, actually to bring the arc into close proximity with the substance as in the well-

known work of R. W. Wood on resonance spectra. The spectrum of the scattered radiation is then readily photographed and shows a multitude of new lines, bands, and in addition continuous radiation. The relation between the frequencies of the incident and scattered radiations will be readily noticed from the equation written above symbolically. The difference between the incident and scattered quanta is equal to the quantum of absorption or emission, or the case may be, of the molecules. The characteristic frequency of the molecule is, therefore, subtracted from or added to the frequency of the incident radiation to give that of the scattered light.

In one sense, this combination of the incident frequency with the frequency of the molecule is an analogue of the classical phenomena of Tartini's Tones which we are familiar with in acoustical theory, and which are explained in terms of the forced vibrations of a non-harmonic oscillator. This analogy may no doubt be used to find the intensity of the modified radiations approximately, by applying the correspondence principle to a non-harmonic molecular model of suitable type. The difference between this classical analogue and the actually observed optical effect is in the extraordinary disproportion between the intensity of the lines corresponding to the differential and summational tones respectively, which is far greater than in the acoustical analogies.

An extremely interesting and fundamental point regarding the new type of secondary radiation is that, in general, it is strongly polarised. In this respect, the phenomenon is analogous to the experimentally known polarisation of the Compton type of X-ray scattering. We notice, however, that the different lines corresponding to different molecular frequencies are polarised to very different extents. It may be presumed that this is due to the molecular oscillators involved not possessing spherical symmetry. Whether this explanation is sufficient or not remains to be tested by computation and comparison with observation.

We may here pause a little to consider more closely the real significance of our phenomenon. Some, no doubt, will claim to see in it a further confirmation of the quantum theory of radiation. My own view, however, is that there is nothing in the effect that in any way contradicts the wave principles, and that on the other hand the fact that we can cut up or add to the quantum of energy to any arbitrary extent is unfavourable to the idea of a real, corporeal existence for it. We may, of course, get over this difficulty by assuming that the incident quantum in some way disappears on collision with the molecule, and that a new quantum of smaller or larger energy arises from the combination. But the observed fact of the strong polarisation of the lines is unfavourable to the latter idea. As already indicated in the foregoing discussions, the concept of localised

quanta is irreconcilable with the phenomena of wave-optics, and the necessity for introducing it is even less in the present case than in the Compton type of scattering.

I shall now pass on to consider some applications of the new effect. Its potential value perhaps is greatest in the field of chemistry. The method of investigation affords us an extraordinarily easy and convenient process of mapping the infra-red spectra of chemical compounds. The geometry of the chemical molecule and the forces of chemical affinity determine the frequencies of molecular vibrations. In many cases, they lie in the far infra-red, a region of the spectrum which has hitherto been difficultly accessible to observation. The study of light-scattering enables us, as it were, to photograph the whole infra-red spectrum with the same facility and ease as the visible and ultra-violet spectra. The determination of the fundamental vibration-frequencies of the chemical molecule, their relative importance as gauged by the intensities of the lines, and even more, their peculiar polarisation characters promise to take us deep into the fundamental problems of chemistry. As an illustration, I will mention a recent paper by Daure in the *Comptes Rendus* of the French Academy. Daure investigated the spectra of the chlorides of Carbon, Silicon, Titanium, Arsenic, Lead, Antimony and Bismuth by this method. The investigation revealed hitherto unknown spectra in the far infra-red for each of the compounds studied, exhibiting remarkable analogies and differences amongst each other in the position, intensity and polarisation of the lines.

In organic chemistry also, the method opens up an illimitable field of research. Numerous lines appear whose positions in many cases are accurately measurable, and are influenced notably by changes in chemical constitution. A very surprising feature is the extreme sharpness of some of the lines. The frequencies of the vibration of the carbon-carbon bond in benzene can be determined, for example, with extraordinary precision unapproachable by other methods. It is precisely this accuracy of measurement and the rich and varied mass of data obtainable that indicate for this method a real future.

The study of the influence of changes of temperature and pressure, and of a change of physical state on the intensity, positions and widths of the spectral lines promises to furnish information of value in the field of molecular physics. Already in our earliest observations it was noticed that the spectral lines obtained with ice are sharper and somewhat displaced in position relatively to the broad bands found with liquid water. The sharpness of the lines observed with transparent crystals appears to be a general feature. As an example I may mention the case of selenite in which Mr. Krishnan found that the water of crystallisation also gave well-defined lines instead of the bands observed with water.

Preliminary studies have shown that it is perfectly practicable to photograph the lines in the spectra of vapours. Hence it will be possible in many cases to investigate the changes in molecular spectra in the passage from vapour to liquid as well as those in the passage from liquid to solid. In the change from vapour to liquid, we have a partial destruction of the freedom of rotation of the molecules. Such observations as we have made seem to indicate that exchanges of energy between the incident quantum and the molecule can also occur with respect to the rotational states of the molecule. The optical anisotropy of the molecule appears to be involved in the possibility of such induced molecular rotation. Whether the removal of restriction on rotational freedom when the molecule passes from liquid to vapour results in a fuller development of such rotational spectra remains to be investigated.

At low temperatures, many liquids as is known refuse to crystallise, become highly viscous and ultimately are transformed into glasses. Glycerine is a typical example of such a liquid. Mr. Venkateswaran has observed in it a remarkable development of a continuous spectrum whose intensity falls with rise of temperature or by dilution with water. The precise origin of this phenomenon and the existence of similar effects at low temperatures in the case of other viscous liquids remain to be studied. The problem of the amorphous solid condition is related to this. Already Pringsheim has noted that fused quartz, unlike the crystalline substance, does not show any lines in the scattered spectrum. The explanation of this may be that the lines have become too broad and diffuse to be photographed.

C. V. RAMAN.

CALCUTTA,
January 2nd, 1929.

Section of Agriculture.

President :—MRS. GABRIELLE L. C. HOWARD, M.A.

Presidential Address.

THE IMPROVEMENT OF PLANTS.

Some years ago several members of the Agricultural Section of the Indian Science Congress came to me with the suggestion that there should be a special section of the Congress for Genetics. They pointed out that under the present organization there was no suitable place for papers on inheritance. The difficulty is a real one. Genetics is a border-line subject and has claims on agriculture, botany and zoology. The classical experiments of Mendel were carried out on peas while insects have furnished much of the material by which the mechanism of inheritance has been demonstrated. The theories underlying the subject are of a very technical nature and pre-suppose a knowledge of botanical and zoological terms and conceptions. Papers on this aspect of the subject are suitable for the botanical and zoological sections. Most of the Indian work takes the form of economic plant-breeding and it is, therefore, chiefly of interest to agriculturists. Thus members interested in genetics are sometimes present in one section, sometimes in another and it is difficult to ensure a good discussion on any particular paper. I can find no sectional address which deals directly with genetics—the nearest approach is the interesting address on *Facts and hypothesis in the problem of evolution* by Father Blatter when President of the Botanical Section in 1925. It is clear that genetics has not been very prominent in this Congress. On the other hand, this branch of science is becoming an increasingly significant factor in the progress of the world. The importance of plant and animal breeding to the prosperity of a nation has long been known. A more recent development is the recognition that modern theories of inheritance are applicable to the study of criminology and to the improvement of the human race. From the scientific aspect also, the development of this science offers a most fascinating field of study. It would be a pity, therefore, if genetics were to remain the Cinderella of the Indian Science Congress. To afford an opportunity for the consideration of this question I have taken one aspect of this branch of science as the subject of my address to-day. I suggest that, at the conclusion of this paper, we should discuss the best methods of making genetics a more prominent feature at the Indian Science Congress and of University teaching in India.

When I began to write this address I was faced with the same difficulty as that experienced in placing genetical papers in this Congress. Should the address deal with the practical side or with the modern theories of inheritance? As so much of the work in India is economic, I have first dealt with a few practical points in plant-breeding. Afterwards, in the second part, I have tried to show how the periodic changes in our conceptions of heredity have influenced practical methods. Genetics is, at present, in a most interesting transition phase and offers a good illustration of the swing of the pendulum. Such oscillations are characteristic of the development of all sciences but research on genetics is of such recent origin that many of the phases are within the memory of the older investigators.

While the biological conceptions underlying plant-breeding have in recent years undergone several fundamental changes, the object of the economic plant-breeder has always remained the same. He desires to produce a variety which will bring an increased monetary return to growers of some particular crop. This increased profit may be obtained by an improvement in yield or in quality. Of the two, yield is the more important. An increased amount of produce per acre is an advantage which the most illiterate cultivator readily understands. It is easily converted into money and does not involve any discussion. It is immaterial whether the increased yield of the new variety is due to potential yielding power, to enhanced disease-resistance or to a more suitable root-system. The extra cash the grower receives is a definite advantage.

The sale of improved quality is a very different matter. It is often extremely difficult to obtain the real value of any improvement in quality. In the first place, no trade agency will pay for improved quality unless there is competition for the product and unless a large quantity of the produce is regularly forthcoming. Owing to the length of time required for the replacement of the original crop by a new variety, a long interval elapses during which the cultivator reaps no appreciable benefit. In the second place, the needs of the market may change very quickly, whereas the breeding of an improved type is a lengthy process. At least ten years are required to establish a new variety. The market demand may, however, be altered in a couple of years by the introduction of new machinery or of new methods of manufacture. Fashion, such as colour or taste in tobacco, may bring about a radical change which cannot be foreseen. In this country especially, where marketing facilities are still undeveloped, the tangible benefit of increased quantity will always conquer the almost intangible and often unmarketable advantages of improved quality. The rapid increase of the area under certain rough, short-stapled cottons in the black soil tracts, where less heavy-

yielding but better cottons, were once grown, is a case in point. The plant-breeder must, therefore, make yield his first consideration. He will strive simultaneously to improve the quality and in most cases there is no reason why yield and quality should not be combined. Speaking generally, no new variety should be distributed in India on the basis of quality only. It is better to wait until this improved quality has been combined with a yield equal to or greater than that of the variety to be replaced.

In addition to yield and quality, an improved variety should possess a third characteristic. This is the power of adaptation to a wide range of agricultural conditions. We here touch one aspect of a very controversial question—centralised or local research. A certain school of thought in India has always considered that, as regards soil and climate, a large number of plant-breeding stations and of improved varieties are necessary for every crop. The practical difficulties in carrying out such a policy are obvious. It is impossible adequately to finance or to staff a large number of small experiment stations and seed stores. There is, however, a more fundamental objection to the multiplication of plant-breeding stations. Modern trade and manufacture demand a uniform product. To come into line with these requirements definite grades must be established at each large trade mart. As these centres draw their supplies from extensive tracts of country, the establishment of definite grades becomes impossible if each locality grows a different variety. The multiplication of varieties actually diminishes the market value of the produce of the tract. Thus from the financial, administrative and commercial standpoints the advantage lies in having a few good experiment stations and extending an improved variety over as large a tract of country as possible. This can only be done if the new type is elastic enough to respond to varying environmental conditions. Such varieties are more difficult to obtain than those suited to a small tract, but experience has shown that they can be produced. I will instance two cases of which I have practical experience. The cane known as S 48 does equally well on the alluvial soils of Rohilkhand and on the black soil areas of Peninsular India. Pusa 4 wheat is being extensively grown in such diverse places as the North-West Frontier Province, Oudh and the well-irrigated areas of Central India. No plant-breeder should, therefore, be content with any variety which is not capable of being grown over large tracts of country.

I will only deal with one further practical point in connection with plant-improvement, namely—the necessity of self-denial in introducing new varieties. There is a very natural temptation to bring forward as a new variety anything which shows even a trifling improvement over that already in cultiva-

tion. This tendency is especially noticeable among young plant-breeders and is easy to understand. Each man wishes to show his employer that he is really accomplishing something. As the work of a plant-breeder is laborious and tedious a small success is hailed with delight. From the point of view of general strategy any such premature attempt to supersede an existing variety is, in the long run, disastrous and generally involves a waste of public funds. It also tends to lower the status of plant-breeding and to shake the confidence of the public. A small increase in yield or in quality is often wiped out or even reversed in bad years. The cultivator knows this and feels that it is better to stick to his old varieties unless the anticipated profit is great enough to justify the risk of change. It used to be an axiom that the Indian cultivator would adopt nothing new. This is not true. If the profit is great enough he will adopt anything but he will not change his seed or his methods unless the increased profit is large. Experiment station workers do not always realise the amount of trouble and expense involved in changing a variety in general cultivation. Members of the audience who have experience of extension work will bear me out when I say that varieties cannot be changed every two or three years without disturbing the confidence of the cultivators and causing very great expense and trouble. It is better for the plant-breeder to wait until he has a really substantial improvement to offer and then to strain every nerve to get it adopted as quickly as possible. The difference between improved varieties is as great as that between the pictures of great artists and those of art students. Only masterpieces should be imposed on the cultivator. There is, however, another side to the question. If plant-breeders are to exercise this self-denial and restraint, the necessity for it must be recognised by their employers. The prospects of a plant-breeder should not depend on the rapidity with which he produces an improved variety. The situation is difficult as popular opinion clamours for tangible results. It can only be met by increased knowledge among the general public and a keener appreciation of the special difficulties of investigators. It should be more generally realised that the essential act in the organization of research is the selection of the man to do the work. Such men when appointed must be given both the time and the means to work out their own salvation. I have dealt with this point at some length because I think it is a real danger at the present time when facilities for plant-breeding are being rapidly extended.

Improved varieties may be produced by two methods: selection and hybridization. An erroneous impression is current that selection is extremely easy and within the scope of untrained men whereas to obtain an improvement by hybridization a mysterious process needing great scientific know-

ledge and insight is required. This is not fair to those who use the method of selection. It is largely due to a confusion of thought in which the breeding of an improved variety is considered to be of the same order as an investigation into the laws governing inheritance. The wording of the section which deals with this point in the report of the Royal Commission on Agriculture in India¹ is unfortunate: "*Hybridization is a much slower process than selection and requires greater scientific experience and a higher level of scientific aptitude. We are however of opinion that the plant-breeder in India will be well advised to adhere to the selection method until its possibilities. . . . have been much more nearly exhausted than is at present the case and that hybridization should only be undertaken by officers, who in addition to special training, have had the experience of Indian crops and conditions which is necessary for successful work.*" It is true that hybridization is a slower process than selection but the impression given that really valuable selection work can be carried out by untrained men is erroneous and if adopted is likely to lead to much waste of time and money. The ultimate success in obtaining an improved variety both by selection and by hybridization demands identical qualities in the investigator: (1) a detailed and first-hand knowledge of the botanical constitution of the crop and of its physiological requirements, (2) insight and judgment in correctly selecting the most promising plants. In both processes the investigator can apply the knowledge gained in studies of heredity. In both he will require a thorough acquaintance with the mechanism of pollination, the range of variation of his material and the response to the environment of the various characters. The difference between the methods of selection and hybridization lies in the nature of the material available. In improvement by selection the investigator is limited to what Nature has provided. Thus selection is of most value in countries where crops as ordinarily grown are a mixture of types or in species in which mutation and natural cross-fertilisation occur. In improvement by hybridization the investigator attempts to combine desirable characters present in different individuals and thus provides for himself the material from which he later selects. Defining the laws of inheritance is work with an entirely different aim and, though in the early days it was possible to combine this with the production of improved varieties, that period has long been passed.² The complicated

¹ Abridged Report of the Royal Commission on Agriculture, Bombay, 1928, p. 79.

² I am not speaking here of investigations which deal with the applicability of certain laws of inheritance to particular crops but to researches which attempt to discover the fundamental laws governing inheritance such as the work of Morgan and Baur.

relationships shown to exist between various characters and the large number of plants involved necessitate for the investigator of the laws of inheritance absolute freedom from economic considerations. Even in the past the attempt to combine profit and the acquisition of new knowledge was unsatisfactory and often resulted in both objectives being missed. In every crop India requires a few first class varieties combining good quality and high yield, each suitable for a large tract of country. It is immaterial whether these improved types are produced by selection or by hybridization but it must be realized that whichever method is adopted varieties of this class can only be evolved by men with a sound scientific training and great natural aptitude. In addition, they must be given sufficient time to produce something really worth distributing. Whichever method is used success depends on the man and his training.

I do not propose to consider the various methods of selection but to pass on to a short survey of some of the changes in the theory of genetics which have influenced economic plant-breeding. Until the re-discovery of Mendel's laws selection was the method most frequently employed in plant improvement. An empirical technique was developed in great detail especially in Germany. Recent research in genetics has swept away most of the old cumbersome methods and modern selection is far more scientific and direct. But it is on the point of stability or the fixing of the variety that present day plant-breeding diverges so markedly from the work of the last century. It is obvious that the degree of usefulness of an introduction is in direct relation to the length of time during which the improvement can be maintained. Before the re-discovery of Mendel's laws by Correns, plant-breeders were working in the dark with regard to this point. Many attempts were made to formulate principles of inheritance as a guide to breeders but these early efforts only seemed to make confusion worse confounded. Certain successful breeders were able to deduce empirical rules as the result of experience but these were generally applicable only to one particular crop. Plant improvement was dependent on the judgment and experience obtained during a laborious apprenticeship by a few men who were often unable to hand on their partly intuitive knowledge.

The nature and stability of hybrids was a particularly debateable point. Most persons held the view that the hybrid was a blend of both parents and attempts were made to determine the percentage inherited from each. The confusion of forms obtained in the later generations and the tendency of the parental forms to re-appear (reversion as it was called) were great stumbling blocks. In all the older investigations the complete individual was considered to be the unit. The re-discovery of Mendel's law of unit characters changed the

whole aspect of the subject. As everyone knows, Mendel, while experimenting on peas in the monastery garden at Brunn, discovered certain principles underlying the inheritance of characters. He found that, if the individual attributes of the plant such as colour, height and so forth, were separately considered instead of the whole plant, the inheritance proceeded in an orderly and even mathematical fashion. Mendel's results made no impression at the time of publication and it was not until 1900 that their re-discovery by Correns brought them to the knowledge of the general public. Time has modified some of Mendel's conceptions and considerably amplified others, but his main conception of the individual as an aggregate of characters, the inheritance of each of which must be studied separately is still the basis on which investigation proceeds. The analysis of a plant into units of inheritance and the technique evolved by the early Mendelians has enabled plant-breeders to obtain stable varieties in a reasonable period of time. From the economic point of view this is the greatest benefit which Mendel has conferred.

I well remember the enthusiasm these early Mendelian researches inspired. If desirable characters could be transmitted unchanged and could be combined, the regeneration of the crops of the world was a simple matter. It was only necessary to find two varieties possessing between them all the desirable attributes and to cross them. The perfect individual containing these characters in homozygotic form could then be extracted from the second generation. It was admitted that there might be a little difficulty in distinguishing between heterozygotic and homozygotic forms in the case of dominant characters but this should only mean a short delay. The greatest scorn was meted out to those old-fashioned investigators who still used selection methods. The millenium as regards crop improvement seemed to be in sight.

After twenty years, plant-breeders are sadder and wiser. It is true that modern plant-breeding has accomplished much. The monetary gain from improved varieties in India alone is estimated to be ten and a half crores a year. Nevertheless we are still a long way from the perfect variety in any crop and the way of improvement is long and arduous and not the simple matter formerly anticipated. The chief stumbling block has been the complex gametic constitution of what Mendel considered to be unit characters. Each character we see, such as flower colour, rust-resistance and so on is not produced by one simple gene but is controlled by a large number of factors. Thus according to Tammes¹ no less than eight factors are involved in the flower colours of linseed yielding 32 genotypically different

¹ Tammes, T. *Bibliographia Genetica*, 4, 1928, p. 1.

coloured forms. This means that the parental form will only re-appear once in a very large number of plants. As the perfect variety must possess many desirable characters each of which may be conditioned by several genes, the number of plants involved may be so great that in practice the required combination never appears. Moreover, characters which appear identical to the eye may be produced by separate genes. For example, the red chaff colour in two varieties of wheat, although similar to the eye, may really be produced by two quite different factors. These two red chaffed wheats, when crossed, produce, therefore, a certain number of white chaffed individuals. It is often quite impossible to determine the gametic difference of similar phenotypic characters by observation. This can only be done by breeding from individuals possessing these characters and then studying the offspring. Generally speaking, the greater the number of genes, the smaller the visible differences and the greater the tendency for them to be obscured by fluctuating variability and by environment.

The existence of what is known as linkage introduces a further complication. It is found that certain characters are inherited together *i.e.*, they are linked. Characters are often linked with sex, but linkage may also occur when sex is not involved. Moreover, linkage may not be absolute. In a certain percentage of the offspring the connection may be broken and the characters may be inherited separately. This is known as crossing over. Again certain genes do not affect one character only but produce an impression on several organs of the plant—that is, their effect is manifold.

Recent investigations have been able to explain these difficulties in a remarkable manner but it is quite obvious that the complications I have just described have made the direct application of the simple Mendelian rules impracticable.

Up to the beginning of this century, plant improvement depended almost entirely on the personal qualities of intuition and judgment in the individual. The really successful breeder either of plants or animals possesses a kind of flair or instinct, probably a sub-conscious integration of various small observations, which are never definitely formulated. The laws of Mendel promised to substitute exact measurements for this intuition and to make successful plant-breeding mechanical. This promise has not been fulfilled. The laws of inheritance are more indirectly than directly useful to the plant improver, who, in the later stages of his work, is thrown back on the once despised selection methods and on his own judgment. The position may be reversed in the future when the detailed gametic constitution of crop plants has been determined. The brilliant work of Morgan and his school has not only shown that the genes or carriers of inheritance are located on the chromo-

somes but that to each gene can be assigned a definite position on an individual chromosome. Thus it should eventually be possible to obtain gametic maps showing the location of all the genes in any particular economic species. It should also be possible to state accurately the gametic differences between well-known varieties. When definite information of this nature is available for all common crops the pendulum will swing again towards greater precision and a more mechanical technique.

In conclusion, I wish to draw attention to some recent investigations which are likely to affect profoundly our conceptions of heredity. As indicated above, the early period was a time of great confusion and controversy. Most of our conceptions were nebulous. The interminable discussions on the nature of variation, on pan-genesis, on continuity of the germ-plasm, on Lamarck's theory of the inheritance of acquired characters and so forth readily occur to all. Then came a period of clarification and definition. Clear distinctions were drawn between fluctuating variability, inherited variation and mutation. Weissman's classical researches showed that acquired characters were not transmitted. Mendel's laws were re-discovered. Johannsen enunciated the law that selection in pure lines is non-effective. Morgan's chromosome theory gave a definite location to the genes and an explanation of linkage and crossing over. Generally speaking, the germ-plasm was considered to be unalterable and its importance in heredity absolute. Effects produced by environmental changes were considered to be impermanent and confined to the generation in which they occurred. With each new discovery the subject became increasingly clear-cut and definite and the number of fixed tenets or principles became larger.

Investigations published during the last few years indicate that we may have to give up or modify some of our most cherished convictions. At first only a few papers were published more or less tentatively but at the present time it is almost impossible to pick up a journal in which there is not at least one communication of a revolutionary nature. I have no time to do more than briefly indicate some of the results obtained. The first paper to which I should like to draw attention is an investigation by Bond¹ on *The influence of pollen maturity and restricted pollination on a simple Mendelian ratio in the pea*. Bond found that the fertilisation of ovules by aged pollen grains produced an increased proportion of seeds with recessive characters. Fertilisation by a minimal number of pollen grains produced the same effect. Bond also obtained some evidence that there is a disproportionate increase in the number of

¹ Bond, C. J. *Jour. of Genetics*, 17, 1927, p. 269.

recessive gametes during the declining stages of the growth of a plant. He points out that if differences arise in the gametes under varying growth conditions then the collection of seeds from different parts of the plant must affect the statistical data and Mendelian ratios.

Investigations concerned with the inheritance of acquired characters form another very interesting group. Most investigators will call to mind the work of Harrison¹ in which by administering manganese chloride to a strain of a certain insect—*Selenia bilunaria*—melanic individuals were produced. This melanism was then inherited as a Mendelian recessive. Lesage² was able to produce new characters in *Lepidium sativum* by the prolonged action of certain salts. These characters were stable and were inherited during a series of years. Here we have something like the inheritance of acquired characters although, as Harrison points out, the effect is not of the Lamarkian type but illustrates a new evolutionary principle that heritable variations may be induced by means of the food supplied.

Undoubtedly the most important modern researches are those dealing with the origin and nature of mutations. The occurrence of mutations has long been known but it has only recently been possible to attempt any real analysis of the various types. From the theoretical point of view the most interesting are the gene or factor mutations, that is, those in which a definite change is supposed to have taken place in the factor itself. At present the cause of such mutations is an open question. Many attempts have been made to induce them by external agencies such as X-rays, radium emanations and temperature changes. Certain investigators³ claim to have very greatly increased the rate of mutation by changes in temperature and by the application of X-rays. Some observers are inclined to deduce a complex constitution of the gene itself from these results. Others are more inclined to consider the change to be of the nature of a modification in a labile chemical compound. Factor mutations are rare. Even when the rate is increased the total number is small. Their present value in plant-breeding is undoubtedly less than that of the mutations produced by variations in the chromosome set or chromosome number. Geno mutation or chromosomal variation may take the form of a multiplication of the ordinary chromosome number or of abnormality. Mutations of this type can be induced by the application of physiological

¹ Harrison, J. W. H. and F. C. Garrett, *Proc. Roy. Soc.* B99, 1926, p. 241. Harrison, J. W. H. *Proc. Roy. Soc.* B102, 1928, p. 338.

² Lesage, P. *Compt. Rend. Acad. Sci.* (Paris) 180, 1925 and Richet-Bachrach-Cardot, *Compt. Rend. Acad. Sci.* (Paris) 180, 1925.

³ Blakeslee, A. F. Variations in *Datura* due to changes in chromosome numbers, *Amer. Nat.* 56, 1922.

stimuli—such as changes in temperature, X-ray treatment and so on to the sexual cells. A very large number of investigations on this subject have been published during the last few years. Among the most interesting are those by de Mol^{1, 2} who showed that the horticultural practices in Holland, which have been so successful in producing new varieties of bulbs, are really methods of producing chromosomal variation. The possibility of inducing at will changes in the chromosome numbers opens out a new chapter in economic plant-breeding. The production of chromosomal variation by external stimuli also suggests an explanation of the origin of species³ and possibly of acclimatization. It may also furnish the solution of the much discussed problem of change of seed in crops like potatoes.

Exigencies of time prevent me from dealing with more of these most interesting investigations but it will be obvious that genetics is entering a new phase in which the effect of environment on inheritance is the main theme. A most interesting field for research is open to investigators. Up to the present, India has taken little or no part in the investigations on which modern theories of heredity are founded and possesses no Institution where such fundamental work can be carried out. The time has come when this *lacuna* should be filled. In the improvement of plants India stands second to none. There is no country in which greater economic results in plant-breeding have been obtained nor which is better equipped with experiment stations for such investigations. The success of this part of the subject has, however, obscured the fact that little or none of the fundamental work on the theory of heredity has been carried out in India. No university has as yet a chair or even a readership in Genetics. For the theoretical conceptions underlying the practical aspects of the subject we have to depend on the work of Europe and America. As the years pass, it will be increasingly difficult to maintain the economic work at its present level unless it is stabilised by a school of pure research in the country itself. Such fundamental research cannot be carried out by the Agricultural Departments or in any Institute devoted to economic aims. The investigator in pure genetics must be untrammelled by the necessity of producing economic results and must not be limited to working only with cultivated plants. Twenty years ago vegetable physiology was an almost untouched subject in India. At the present time this aspect of botany is fully and worthily represented.

¹ Mol, W. E. de—Duplication of generative nuclei by means of physiological stimuli and its significance, *Genetica*, 5, 1923, p. 223.

² Mol, W. E. de—The originating of diploid and tetraploid pollen grains in Duc van Thol tulips dependent on the method of culture applied, *Genetica*, 11, 1928, p. 119.

³ Rosenberg, O. Speziesbildung mit Vervielfältigung von Chromosome, *Ztschr. f. ind. Abst. u. Vererbgs.* Supp. 1, 1928, p. 332.

We now require a living school of genetics from which economic workers and students can draw inspiration. Heredity is one of the great forces which moulds the human race. No more worthy object of endowment can be conceived than the establishment of a Chair of Genetics at one of the Universities. I hope that before the Congress meets again at Madras some wealthy corporation or public-spirited donor will have it made possible for us to have a Professor of Genetics among our members.

Section of Agriculture.

Abstracts.

1. Recent agricultural development in Madras.

R. D. ANSTEAD, Madras.

Owing to the wide range of climatic and physical conditions, a large number of crops are grown with a consequent wide range of agricultural problems. Paddy, millets, groundnuts and cocoanuts are the main crops. Much attention has been paid to crop improvement by selection and hybridisation. A number of subsidiary breeding stations have been established for paddy and cotton. Recently similar work has been undertaken with millets, groundnuts and cocoanuts. A method of growing cocoanuts under dry farming conditions has made their cultivation possible over hitherto waste areas. Many improved strains of paddy and cotton have been evolved. Seed farms have been established to meet the growing demand for seed. Attempts are being made to persuade Co-operative Societies to undertake the work of seed multiplication and distribution.

Legislation to control diseases of cotton and the mixing of pure types has proved unpopular.

Cultural improvements of cotton are now being taken up especially the time of sowing. The use of iron ploughs is closely linked with cattle improvement. The fodder question and the possibilities of silage are being studied.

The introduction of improved high-yielding strains emphasises the necessity for intensive manuring and the use of artificials is under investigation. A special experiment station subsidised by supplying firms is being started to test the new fertilisers now coming on the market.

The effect of manures on the food value and vitamin content of the resulting grain has received special attention (in collaboration with Lt.-Col. McCarrison). A certain amount of organic manure appears to be essential. The bearing of this on all manurial systems is under investigation. A method of making "Synthetic Farm Yard Manure" is being demonstrated to the ryots. An activated sludge plant is being installed at Coimbatore.

A study of local problems in Animal Nutrition is being undertaken.

The biological control of a caterpillar attacking cocoanuts on the West coast by means of its natural parasites introduced from the East coast has proved successful.

The fungoid disease attacking areca palms has been controlled by large scale spraying. The bud-rot of palmyra palms is controlled by a special staff.

RICE.

2. Some aspects of the rice problem in Sind.

T. F. MAIN, Poona.

The Lloyd Barrage at Sukkur and associated irrigation will bring about a revolution in the agriculture of Sind which will then assume a position comparable with that of Egypt. The province already grows some excellent varieties of paddy and this crop now occupies 12 lakhs of acres. Many important problems are associated with this crop, and some of these are under investigation. This paper refers to some of these investigations including examples pertaining to irrigation and economics.

3. A simple and inexpensive method of green-manuring the broad-casted rice crop.

D. R. SETHI, Gaya.

In deltaic Orissa rice is the only crop grown. The seed is broadcasted at the beginning of the rains and the seed rate is very high—82 to 123 lb. per acre. The crop is thinned by ploughing through it towards the end of July. As the ordinary method of green-manuring the fields and then transplanting the paddy seedlings is not practicable under Orissa conditions, a simple and inexpensive method of manuring the crop has been evolved at the Cuttack Experiment Station. This consists of mixing 10 lb. of *dhaincha* (*Sesbania aculeata*) seed with the rice at the time of broad-casting. The *dhaincha* plants are allowed to grow with the young rice and are ploughed in at the time of thinning the crop. Any plants that are left unploughed are buried by hand at the time of filling up the blanks and of weeding. Those along the field *bandhs* are usually allowed to grow in order to provide seed for the next season. The method is inexpensive and does not necessitate any extra labour or change in the existing practice. The extra yield is 205 lb. of paddy per acre.

4. The nature of the action of green manure on paddy soils.

B. VISWA NATH and S. KASINATH AYYAR, Coimbatore.

Twenty years' work bearing on the study of the chemistry of green manuring paddy lands is discussed. Stress is laid on the practical application of this knowledge. The lines of future work are indicated.

5. Some biological aspects of *Punja* or swampy paddy soils in Travancore with special reference to nitrogen assimilation.

K. R. NARAYANA IYER, Travancore.

Much of the rice cultivated in Travancore is grown in *Punja* lands, swampy areas connected with backwaters and subject to floods during the rainy season. These lands are submerged for about eight months and yield only one crop which occupies the ground from December to March. Cultivation is carried out by embanking the fields and then bailing out the water with an oil engine. A preliminary study of four of these areas shows that:

- (1) the assimilation of nitrogen by paddy in *Punja* soils is almost entirely as ammonia and not as nitrate.

- (2) the total nitrogen of *Punja* soils increases by about 20 per cent during the growth of the crop. This increase is due to the activities of anaerobic nitrogen-fixing bacteria and certain fungi.

- (3) the presence of small quantities of ammonia at the beginning of cultivation, the formation of large quantities of ammonia after transplanting and the decrease in ammoniacal nitrogen towards harvest time show that the ammoniacal nitrogen is mostly assimilated between transplantation and seed formation.

- (4) the nitrogen content of the soils increases during the growth of the crop and falls off rapidly towards harvest time owing to de-nitrification.

- (5) the high degree of ammonification, the complete absence of nitrification and the presence of toxic substances in two of the soils show that the biological activities in these soils are mostly due to fungi and not to beneficial bacteria.

- (6) a fair amount of nitrogen fixation takes place in all the soils.

This fixation is due to anaerobic bacteria and certain fungi not to *azotobacter*. This nitrogen fixation is at its highest during the growth of the crop.

6. Note on the agricultural and botanical classification of rice in Bengal.

G. P. HECTOR, Dacca.

Rice is the important crop of Bengal, occupying over 22,000,000 acres. In India it stands first in area. Agriculturally this large area can be subdivided into five distinct agricultural crops, each with its own characteristics. These are (1) The highland *aus* or early crop, (2) transplant *aman* (winter), (3) lowland *aus*, (4) lowland *aman*, (5) *boro* or spring rice. There are many botanical varieties belonging to each class, which are specially adapted to their peculiar conditions, and which will grow only under these conditions. Though varieties of one class may morphologically resemble those of another, physiologically they are totally distinct. Hence any classification must be based primarily on the agricultural group to which the variety belongs. The number of morphologically distinct varieties within the groups, though large, is not so large as is commonly supposed, but the number of pure line types which can be selected out from within a botanical variety is very large. The characters on which a botanical classification of varieties should be based are noted and also the main characters by which types within varieties are differentiated. Important differences in the flowering date of *aus* and *aman* varieties are briefly discussed.

7. A note on selection of rice in Bengal.

G. P. HECTOR, Dacca.

Some results obtained in Bengal show the great possibilities of simple selection in the improvement of the rice crop. Work at Dacca has consisted both of intervarietal and intravarietal selection, between which no hard and fast line can be drawn. In the note, instances are discussed which show the great variability of the ordinary botanical variety of rice. It has been shown that from within one variety, types differing markedly in such characters as average number of grains per tiller and date of flowering and ripening, can readily be selected out.

8. Germination of paddy in relation to outturn.

S. G. SHARANGAPANI, Dacca.

Two recommended paddies of the Bengal Agricultural Department, one *kataktara*, a highland *aus* (early), sown broadcast in April-May and harvested August-September, and *indrasail*, transplanted *aman* (winter) paddy, sown in seed-bed in May-June, transplanted in July-August and harvested in December, were selected for this purpose.

Seeds were harvested at intervals of a week, beginning on the 19th day from the average date of flowering, to the final date of harvest. After thorough drying, the germination was tested week by week until the normal sowing time. It was observed that seeds harvested 19 days after flowering and onwards were as good as those harvested 54 days after flowering. Field trials show that the outturn from crops harvested 19 days after flowering is low, about half of the normally harvested crop. It increases gradually until it reaches its maximum 40 to 47 days after flowering. It was further observed that the outturns at any one date of harvest remain fairly constant irrespective of the age of the seed sown. The results are of value as showing (1) that if unfavourable years are predicted, seeds may be harvested for seed purposes as early as 19 days

after flowering, (2) the maximum outturn is obtained at 40-47 days after flowering.

9. Studies on the root-system of paddy.

R. L. SETHI, Cawnpore.

No attempt has been made up to the present to study the roots of paddy. For a scientific understanding of the growth of the crop, a knowledge of the development of the root-system is necessary. The root-system of the rice plant has, therefore, been studied under varying conditions of growth. A short *résumé* of the methods employed by different workers for studying the root-system in other crops is given, and the method employed by the author is described. The development of the different types of roots, the amount of lateral branching, the degree of penetration, and the colour produced by different soils, manurial treatments and varieties is described. In addition to dealing with the broad facts of root distribution, and its relation to various soil types, the influence of such factors as soil texture, soil moisture, soil aeration, and soil temperature is discussed. The anatomy of the roots of rice is compared with the anatomy of the roots of land and water-plants.

10. A note on Bora or Birain (*Oryza sativa* var. *glutinosa*).

S. K. MITRA, Jorhat.

Bora or *birain* paddy is grown in Assam in both the Surma and Assam valleys. Except in *aus* it is found in all classes of paddy. Thus *sail bora*, *asra bora*, and *boro bora* exist. It is glutinous rice and is highly valued by the Assamese cultivators. It has great industrial possibilities.

11. A preliminary note on the toxic effects of aluminium on rice in relation to the reaction of culture media.

S. K. MITRA and L. N. PHUKAN, Jorhat.

Preliminary experiments on the toxic effect of aluminium on rice seedlings were conducted with a 0.001 M solution of aluminium chloride under different reactions of culture media. The adjusting medium was caustic soda with a concentration varying from 0.001% to 0.05%. The p^H values ranged from 4.0 to 8.4. The experiment was continued with one-month-old seedlings for three weeks. The total length of the roots and the general appearance of the plants were taken as the criteria of growth.

Aluminium is toxic to rice only within a definite range of p^H values. At acidities less than p^H 4.8 the seedlings suffered strong acid toxicity as well as aluminium toxicity. At acidities greater than this amount and up to p^H 7.8 the toxicity due to aluminium was at its minimum. Above p^H 7.8 the seedlings suffered aluminium toxicity alone. This was shown by the previous work of the writers where it was found that the retardation in growth of the seedlings within this range of p^H values could not be due to the toxicity of the hydroxyl-ion.

The results corroborate the work of Majistad who found that soils or other nutrient media, with reaction values within the range p^H 4.7 and p^H 8.5, do not contain aluminium in soluble form, and are, therefore not toxic to plants.

The present work suggests that the acid soils of Assam do not contain soluble salts of aluminium in toxic amounts as the p^H values of Assam soils rarely fall below p^H 5.0 or go above p^H 7.8.

12. Maturity test of rice.

S. K. MITRA and P. M. GANGULI, Jorhat.

The maturity of rice is an important question in the inundated areas of the Surma valley where the annual early floods destroy the rice crop, especially the *aus*. Experiments have shown that under Surma valley conditions the mature grains attain the average weight on the 26th day in *aus* (autumn rice), the 30th day in *sail* (winter rice) and the 34th day in *asra* (winter rice—shallow water *aman*). Of the collected grains a 90% germination was obtained on the 30th day in broadcasted *aus*, on the 32nd day in transplanted *aus* and *sail*, and on the 38th day in *asra*. Moreover, no loss of weight or decrease in the percentage of germination is found in any of the above classes of paddy even up to the 50th day after flowering.

13. The periodic growth of rice.

S. K. MITRA and P. M. GANGULI, Jorhat.

A rice plant grows slowly though not uniformly until about a fortnight before flowering, when the growth is much increased. The maximum rate of growth is obtained in the week of flowering. The plant ceases to grow a week after flowering. The maximum growth of the leaves is attained on the seventh week both in *aus* and *sail*. The longest leaf in *aus* is the twelfth, the third leaf from the flag. In *sail* it is the thirteenth or fourteenth leaf. Under ordinary conditions plants begin to tiller a week after transplantation. The highest number of tillers is obtained on the seventh week in *aus* and the eighth week in *sail*. Much space round the plant favours tillering, though some of the late tillers either die or flower too late. The mother culm does not necessarily flower first. Flowering lasts for about a fortnight though some late tillers flower after that. Flowering is more vigorous in the first week than in the second. The flowering spike takes two or three days to emerge completely from the sheath. Except for the longer period of vegetative growth that causes the *sail* paddy to flower late, there is no difference between the two classes of rice—the *aus* and *sail* in the periodic growth.

14. Progress of rice-breeding in Sind.

K. I. THADANI, Sakrand.

Rice occupies one and a quarter million of acres in Sind as an irrigated crop. Several varieties are found in Sind, some of the characters of these varieties have been described. The flowers of the rice plant open early in the morning and close after midday. No flowers open after 2-30 p.m. The actual time taken by a single flower to open and to close completely varied from 32 to 70 minutes. The proportion of sterile spikelets remaining on the earhead after harvest varied from 6 to 30%; the standard varieties showed 12.6 to 19.6% sterile spikelets. So far sterility has not been connected with any insect or fungoid attack. Defective pollination and abortion after fertilization were the chief sources of sterility observed. Field plot technique in rice breeding is discussed. Statistical figures are given showing the extent to which the various characters are constant in a pure line. Improvement by selection has resulted in the production of strains giving an increased yield of 14 to 32 per cent over unselected seed. Trials of exotic rices have not been very successful. To obtain a higher yield crosses have been made between selected strains and other varieties possessing high tillering and more grains in the earhead.

15. Some experiences in rice-breeding.

K. VENKATARAMAN, Madras.

Breeding work on rice is subject to local or territorial limitations and the problem of rice-improvement in general has, of necessity, to be tackled piece-meal on the basis of typical paddy-tracts possessing of fairly similar soil conditions. The economic aspect of the work consists in the isolation of high-yielding pure strains by single-plant selection, or hybridisation. The ordinary ryots' crop suffers deterioration by being a mixture of several varieties differing from one another in grain-size, duration and yield. The material for the breeder's work of selection is easily provided by collections of ryots' varieties. The processes of evolving superior and improved strains from this medley are described in the paper, with special reference to practical details. The main stages in the work are single-plant selection, plant-to-row multiplication, fixing pure line cultures, selecting lots for yield tests, conducting and continuing strip trials, and the comparison of results.

COTTON.

16. The effect of the environmental conditions of the Punjab on the growth of cotton.

TREVOR TROUGHT, Lyallpur.

17. The progress of cotton research in Sind.

K. I. THADANI, Sakrand.

One of the most important problems in Sind is to find the best type of cotton for the new canal areas. Egyptian cotton is affected by white ants which reduce the stand percentage to 24. The yield is about 1380 lb. of seed cotton per acre, whereas Punjab-American yields about 1921 lb., the stand percentage being 58. Several varieties of these cottons and some imported American cottons are under trial. In Central Sind, sowings made in the month of March and April are not so successful as sowings in the month of May. A number of single plant selections of promising varieties are under trial. A strain of 4F possessing a staple over $7\frac{3}{8}$ " seems to be the most promising. Crosses have been made between 4F and Meade with the object of improving the staple of 4F cotton as this seems to be the hardest and most prolific cotton for Sind. Non-dehiscence of anthers in the flowers formed in July and August was first noticed at Sakrand in 1926-27 and has been confirmed during the season 1927-28. The effective flowering period was the same in both the April and the May sowings. The development of the seed was found to be subject to seasonal variation.

18. The relation between the position of the seed in a lock and its weight in cotton.

V. RAMANATHA AYYAR, Koilpatti.

With a view to ascertain the fluctuations in the seed and lint weights per seed in a lock, the seeds in several locks of *G. hirsutum* and *G. cernuum* were examined. It was found (1) that the seed weights were highest in the seeds located about two thirds from the distal end, (2) that the lint weights attained their maximum on the seeds situated very near the proximal end, (3) the seeds at the top possessed the smallest seed and lint weights and, (4) the ginning percentages were higher in the lower portion of the lock. These observations should be borne in mind when samples are taken for the determination of seed weight and lint index.

19. The relation between ginning percentage and staple length in Dharwar cottons.

G. L. KOTTUR, Dharwar.

The correlation between ginning percentage and staple length has been studied in Dharwar cottons. The results do not indicate any significant and reliable relation between these characters. In all probability the two characters are genetically independent in *Kumpta* and *Dharwar-American*. The three pure lines of *Kumpta* showed a considerable amount of variation in their coefficients of correlation during the four years they were under investigation. In the year 1924, which was unfavourable for both characters, a correlation was obtained which is remarkably different from that obtained in the other three years. This difference, which is clearly due to the season, shows the necessity of giving proper consideration to physical conditions.

20. The use of selfed seed in maintaining the qualities of improved cottons.

G. L. KOTTUR, Dharwar.

Cottons often deteriorate under cultivation, the causes being natural cross-pollination and the mixing of seed. Both these factors obtain in any tract which grows two or more cottons. They can be controlled to a great extent by maintaining a regular supply of pure seed from the central seed farm. The two improved cottons of the Bombay Karnatak, which cover a large area, have retained their characters for more than ten years. This is due to the use of selfed seed on the farm and the careful multiplication of it, for two years only, in cultivators' fields. The large quantity of selfed seed required for sowing on the farm is obtained by ringing the buds at a cost of rupees two per pound. Pure seed thus produced is further multiplied, first on the selected seed growers' fields and then on the larger area specially reserved for the purpose. After that it goes into general distribution. In this way the purity of the cotton has been maintained in a very satisfactory manner.

21. The effect of time of sowing on some economic characters of the cotton plant.

C. JAGANNATHA RAO, Koilpatti.

In this paper, a brief record of the effect of the time of sowing on some economic characters of the cotton plant is given, the sowings being made at intervals of about a fortnight during one season. Observations showed that the time of sowing affects the position of the first fruiting branch node and the phases of flowering and bolling. It does not seem to affect the maturation period of the bolls or the weight of *kapas* per seed. In the case of length of fibre, lint weight, seed weights and ginning percentage, the results are not definitely conclusive; although in the majority of cases deferred sowing seems to have no marked effect.

22. The bio-chemical factors involved in the resistance of the cotton plant to the attack of stem-weevil.

B. VISWA NATH, Y. D. WAD and M. SURYANARAYANA,
Coimbatore.

The results of four years' investigations on the bio-chemistry of the cotton plant indicate that the state of health of the plant can be traced

to the relative intake of the bases, potash, lime and magnesia, with reference to phosphoric acid. When the physiological balance is upset as a result of the attack by the stem-weevil, there is a tendency for the basic constituents to move from the leaves to the stem, the seat of injury, thus resulting in an accumulation of basic constituents in the stem at the expense of the leaves. In the case of phosphoric acid the reverse is the case.

The determination of the Hydrogen ion concentration in the extracts of the leaves and stems of the attacked and healthy plants support this view.

The greatest difference over a healthy stem as regards chemical constituents is shown by the bulb or the nodular swelling, *i.e.*, the damaged portion of the stem. The results of statistical examination are given.

OTHER CROPS.

23. Crop improvement and variety testing.

B. C. BURT, Patna.

It is suggested that in plant breeding work for the improvement of the major crops in India more certain success might be expected if the process of introducing an improved variety into cultivation were visualised and certain inevitable limitations appreciated. Reference is made to the desirability of planning field experiments with reference to the method of statistical interpretation to be adopted and on the importance of reducing experimental error as well as evaluating it.

The need for future research on the factors which determine agricultural yield and the quality of agricultural produce is emphasised.

24. Yield factors in cane cultivation and their relation to experimental trials.

S. KASINATHA AYYAR, Coimbatore.

The importance of an analysis of yield factors is emphasized. An attempt has been made to apply it to the cane crop. Statistical estimates of the contribution of each of the factors has been obtained as far as data are available.

25. The effect of manuring on the quality of the crop.

B. VISWA NATH and M. SURYANARAYANA, Coimbatore.

The paper deals with further investigations on the influence of manuring on the resulting crop. Whereas in the previous publication (Memoirs, Department of Agriculture, India, IX, No. 4, 1927) the seeds tested were obtained from plots under emphasised manurial conditions, the seeds now selected came from normally manured fields from different localities, *viz.*, Nandyal, Koilpatti, Hagari, Pusa and the wet lands of the Coimbatore Central Agricultural Station. In all cases the crop from "Cattle manure seed" was superior to that from "No manure seed." Besides cattle manure, other organic manures like synthetic farm yard manure and oil cakes, and combinations of organic and mineral manures were tested as regards the quality of the seed, the results are reported.

Another aspect of the investigation was to ascertain the effect of manuring the seed-bed on the growth of the seedlings when they are transplanted into a field of ordinary fertility. Experiments conducted for three years on *Ragi*, in small plots gave encouraging results.

26. Ear-head shapes and their inheritance in *Bleusine coracana* Gaertn.

G. N. RANGASWAMI AYYANGAR and P. KRISHNA RAO,
Coimbatore.

Three readily recognisable head shapes are met with in this cereal. The inheritance of these three types has been found to follow Mendelian lines. Their genetic inter-relationships are discussed.

27. Cultivation of Indian broom-corn under European, African and American conditions.

S. S. NEHRU, Rai Bareli.

In the last paper on tests with broom-corn, *Andropogon sorghum* var. *techn.*, the results of experiments made in different countries and under different conditions, notably at the Rothamsted Experiment Station, England, the Botanical Gardens of the University of Heidelberg, Germany and at the Seed Station of the Agricultural Institute of the Governor-General, Algiers, were communicated. Encouraged by the good results obtained from these tests, seed for extensive cultivation has been taken by the Agricultural Institute in Algiers and by a leading firm of manufactures of brooms and brushes in the Vosges hills of France. The results of this extensive cultivation will be communicated and samples will be shown. In America, the U.S. Bureau of Agriculture, Foreign Crop Introduction section, is making special experiments with the same type of seed in a selected farm in Woodward, Oklahoma. The results of these experiments will also be communicated. The Indian type, as evolved by the writer, yields a better fibre than the American type, of which the defects have been discussed in the *American Journal of Heredity*, XIV, 1923, pp. 213-219.

28. Pusa versus *desi* wheat in Oudh.

L. C. SHARMA, Partabgarh.

A short account is given of the conditions under which wheat is grown in the United Provinces. The introduction of Pusa wheats (Nos. 4 and 12) together with improved cultivation will give an increase of Rs. 2,806,000 in the District of Partabgarh alone. The chief advantages of the Pusa wheats are (1) economy in the seed rate (2) higher yields and (3) better prices. Details are given of a comparative experiment between Pusa and *desi* wheats conducted by the Registrar of Co-operative Societies in the villages of Khajuri, Niwai and Bishavanathganj. This illustrates how co-operation between the Agricultural and Co-operative Departments is assisting rural uplift.

29. Seed storage and distribution.

N. K. SHARMA, Jhansi.

30. White glossy fibres from *Ethal-padrua* stalks.

(Preliminary communication.)

P. NEOGI, Calcutta.

The straight branches or stalks of the *Ethal-padrua* (which is cultivated as a garden plant for its large rose-coloured flowers) have yielded glossy, white, jute-like fibres when steeped in water for about a fortnight

and washed in much the same manner as jute. It is a perennial shrub-forming tree which throws out numerous perfectly straight branches, often measuring 5 to 8 feet in height, the bark of which yields the fibre. As the tree grows on all high lands, even waste lands and as successive crops of new stalks are available every year from the same tree without further cultivation it might be cultivated experimentally on a large scale as a fibre plant. The fibres are quite strong and much whiter than jute. They can be converted into string and cordage and can be woven into gunnies and gunny cloth.

FODDERS AND FORAGE.

31. The estimation of iodine in fodders and feeding stuffs.

P. E. LANDER, RAMJI NARAIN and SHER SING MANGAT,
Lyallpur.

The writers have critically examined the various methods in vogue for the determination of the small quantities of iodine present in feeding stuffs and similar materials, and have introduced certain modifications in the methods where defective processes occur, or processes which appear likely to cause a loss in the iodine at various stages. The method as finally evolved gives results in duplicate determinations of a satisfactory degree of accuracy, and enables the detection and estimation of 90% of iodine added to a sample.

The method is a modification of the methods recommended by Leitch and Henderson and McClendon, the essential difference from those methods being the fact that the potassium iodide present in the ash is not dissolved directly in alcohol, but first dissolved in water, which is then evaporated down, the residue being taken up in alcohol: provision is also made against loss of iodine during the process of liberation by nitrous acid and absorption in carbon tetra-chloride, by devising a special absorption tube which can be kept closed during this latter operation thus ensuring the retention and absorption of the whole of the iodine.

32. A preliminary note on the wild grasses of Assam.

S. K. MITRA, and D. M. SEN GUPTA, Jorhat.

A systematic study of the wild grasses of Assam has recently been taken up at the Botanical Laboratory at Jorhat as a preliminary step towards further study for the improvement of the grazing areas of the province on the basis of ecological conditions.

Except for the new alluviums and the flooded low lands, the soils of Assam are mostly acid. Extensive grass lands are met with consisting mainly of poor fodder grasses, such as *Imperata arundinacea*, *Erianthus Ravenneae*, a few species of *Saccharum*, etc. The majority of the better fodder grasses, viz., *Paspalum*, *Panicum*, *Digitaria*, *Setaria*, *Cynodon*, etc., are limited to a few favourable situations, such as the homestead or garden soils and the margins of streams and hills, where the soils are richer and less acid.

In the present paper an attempt has been made to discuss briefly, with special reference to their fodder value, forty seven species only out of the large number collected.

CATTLE.

33. The proper role of livestock in Indian agriculture.

G. S. HENDERSON, Pusa.

General view of the present position of livestock in India and its relation to agriculture. Comparison with other countries and similar tropical

countries. Evils of present position, resulting in a low standard of fertility and low crop production. Possibility of improvement. Improvement in feeding and management. Fodder crop and cereal crops. Silage and storage of hay and dry fodder.

34. Tests with the pepsin method for determining digestibility of protein.

A. VISWANATHA IYER and N. KRISHNA AYYAR, Bangalore.

Preliminary tests with the method as generally employed gave irregular results when applied to faeces. The errors were found to be due to difficulties in washing the residue. They were overcome by the use of N/10 HCl as a wash liquid. Tests made with different strengths of pepsin HCl showed that N/5, N/2.5 and N pepsin HCl gave the same result at the end of 72 hours. Practically no more protein was dissolved by increasing the time. The constancy attained in these tests was not due to the presence of insoluble protein but to the attainment of an equilibrium. Successive fractions could be dissolved out, (a) by repeated additions of pepsin, (b) by filtering and using fresh re-agent, (c) by greatly extending the time.

Therefore absolute figures for insoluble protein cannot be obtained by this means. There is some prospect that the constant attained under standard conditions may have a value for comparative purposes. Work to test this possibility is proceeding.

35. A study of the quantities of Hippuric acid excreted by cattle

N. C. DAS GUPTA, Bangalore.

In certain cases it was found that the Hippuric acid nitrogen formed a relatively large fraction of the total nitrogen excretion. It seemed possible therefore that Hippuric acid excretion may at times materially affect the Nitrogen balance of cattle. For this reason a study of Hippuric acid excretion has been undertaken by the nutrition section at Bangalore. Some preliminary results are worth recording. It has been found in the first place that Hippuric acid excretion is practically unaffected by increasing the protein. Numerous figures to illustrate this point have been procured. Secondly, it has been found that Hippuric acid excretion is definitely related to the nature of the coarse fodder. For example, samples of *Ragi* straw and Meerut grass-farm hay yielded less Hippuric acid than was obtained from *Jowar* and *Bolarum* hay. The non-nitrogenous fraction of concentrates may also exert an appreciable effect. A further point recently observed is that the Hippuric acid excretion may vary considerably when the same fodder is tested at different stages of maturity. The work is being continued.

POULTRY.

36. The advantages of poultry farming as a rural industry.

A. K. FAWKES, Lucknow.

Suitability of poultry keeping for persons of small means.

How the present marketing of eggs should be improved and organised and an export trade built up.

Statistics of approximate production in the various provinces.

Statistics of overseas demands.

As the standard of living improves and as education spreads so the demand for eggs as food is on the increase in all parts of the world. India is moving with the times. This movement should be catered for.

The poultry industry should be taken seriously, and definite organisations for its encouragement adopted by each local Government, as advised by the Royal Commission on Agriculture.

37. The organization of Provincial departments of poultry husbandry in India.

D. G. ANSELL, Lucknow.

Outline scheme of a poultry department for each Province.

Importance of experimental farms.

Practical extension to villages.

Results of work already done in the United Provinces.

SOILS.

38. Correlations of rainfall in different periods.

B. H. WILSDON and R. P. SARATHY, Lahore.

A statistical study of the rainfall in the Punjab tends to show the high degree of correlation that exists between the rainfall in the different periods of the monsoon. Significant correlations are obtained between the total rain falling before certain dates and that falling afterwards. As a result of this study we are able to say with a high degree of confidence that if the monsoon is in excess or in defect of the normal up to the "middle of July," it will be in excess or in defect during the remaining period also.

39. Study of the movement of water and soluble salts in the soils at the Agricultural Research Station, Sakrand.

V. A. TAMHANE, and J. A. DAIJ, Sakrand.

Millions of acres in Sind will come under cultivation when the Lloyd barrage scheme comes into operation. It was therefore considered advisable to study the effect of different quantities of irrigation water at Sakrand. Irrigation water in quantities of 8", 6" and 4" were given to the virgin land. The upward and downward movement of soil moisture in the five foot column of soil was determined at intervals of 24 hours, 48 hours, one month, and four months after irrigation. Mechanical and chemical analyses, (including soluble salts present in the soil as well as the maximum water-holding capacity of the soil layers) were made to illustrate the nature of the soils under experiment. The results show that, if a soil mulch is kept on the surface of the land, the general loss of moisture from the lower layers is confined to a depth of two feet. Below this, the moisture contents, except for a certain loss during the first ten days after irrigation, remain constant for four months. In *kalar* or salt lands 4" or 6" of water is not enough materially to reduce the quantity of soluble salts. Eight inches of water seems to be the minimum quantity of water required to make any material reduction in the total soluble salts in a fairly permeable soil.

40. Soil survey of the Nalkantha District (Limbdī State).

C. V. RAMASWAMI AYYAR, Bangalore.

The results of the chemical and mechanical analyses of the above soils are discussed. In common with many other Indian soils examined, the figures indicate a general deficiency in nitrogen and phosphate. The mechanical analysis indicates that the present classification of the soils is faulty. A more scientific and rational scheme has been proposed

which brings out the close correlation existing between the mechanical and chemical composition and soil fertility.

41. A new percolating cylinder and some of its uses.

A. N. PURI, Pusa.

A new percolating cylinder is described and some of its uses enumerated.

Particular attention is drawn to the measurement of a factor relating to soil texture.

42. A new method of dispersing soils for mechanical analysis.

A. N. PURI, Pusa.

NaOH and LiOH are much more powerful dispersing agents than ammonia which is almost universally employed for final dispersion in the mechanical analysis of soils.

A method of preliminary treatment of the soil for mechanical analysis is outlined, which consists in replacing all the ions by Na in the exchange complex.

The proposed method combines all the advantages of acid treatment as regards reproducibility and attainment of maximum dispersion and is free from such objections as the loss of varying amounts of soil constituents that are inevitable when the soil is treated with acid.

43. A study of the nature of certain peculiar low-lying lands of Central Travancore.

T. R. NARAYANA PILLAI, Bangalore.

These lands comprising an area of about 700,000 acres, are subject to floods in the monsoon season and inundation of sea water due to the tidal influence in the summer. The area is mainly under paddy, and the crop though once yielding well has of late begun to fail. The physical, chemical, and biological characteristics of these soils have been studied with a view to their amelioration.

44. Lime requirements of two acid soils as found by the nitrification test and by chemical methods.

N. V. JOSHI, Pusa.

The lime requirements of two acid soils from Netarhat were found by four different chemical methods and by the nitrification test. Of these Hutchinson and McLaren's method and the ammonia absorption method show a correlation with the nitrification method. The highest amount of lime in the form of Ca added to both soils showed a definite inhibitory effect on nitrification indicating that there is a limit to the addition of lime above which bacteriological processes may be inhibited.

45. A simple method of water culture.

N. V. JOSHI, Pusa.

A simple method of growing plants in nutrient solutions has been devised. A piece of wood coated with paraffin in which holes have been

drilled to hold the plant is used to cover a jar containing the nutrient solution. Corks coated with paraffin or paraffin blocks used by previous investigators were found to be coated with bacterial slime. This may interfere with the growth of the plant by competing for the nutrient material even if it has no other deleterious effect. The chief advantage of the arrangement described is that nothing comes in contact with the nutrient solution except the root of the plant to be grown and nothing comes in contact with the stem of the plant except sterile cotton wool.

46. Further experiments with home-made superphosphate.

N. D. VYAS, Pusa.

The work described is a continuation of that presented in a paper read at the Science Congress at Lahore in 1927 and deals in detail with the investigations carried out by the writer for rendering the unavailable phosphoric acid of the bonemeal available, by composting it with sulphur, sand, charcoal and sulphur oxidising organisms.

The experimental data, reported in this paper, show that by composting bonemeal not only is its phosphoric acid rendered available but its nitrogen as judged by the nitrification in the soil also becomes readily available. The fertilising power of the composted bonemeal for different crops has been established by a number of field experiments. It possesses a higher fertilising value for potatoes, oats, wheat and onions than superphosphate or bonemeal alone. Trials with crops other than potatoes were conducted at Pusa; those with potatoes at three different stations in Bihar and at one station in the United Provinces. At all these stations the bonemeal-sulphur-sand-charcoal compost proved its superiority over superphosphate or bonemeal.

47. An improved method for the determination of available phosphoric acid in soils.

SURENDRALAL DAS, Pusa.

A large number of typical soils of known cropping and manurial history (acid, laterite, humus, alkali, calcareous, and non-calcareous, were collected from different parts of India with the object of comparing the new potassium carbonate method with Dyer's Citric acid method.

1. The results obtained showed that the potassium carbonate method is equally applicable to all types of soil, whereas the citric acid method breaks down as a discriminating agent for evaluating the available phosphoric acid in the case of alkali and calcareous soils.

2. In addition to the obvious advantage of a more general application, the potassium carbonate method possesses several other points in its favour and should, therefore, replace for the estimation of the available phosphoric acid of soils the existing Dyer's method or any of its substitutes which depend upon acid digestion.

48. A critical examination of lime requirement method for acid soils.

SURENDRALAL DAS, Pusa.

49. Application of sulphur for neutralising alkali in soils.

K. R. NARAYANA IYER, Travancore.

There are about ten thousand acres of alkali soils in a more or less barren condition in S. Travancore. The unproductivity of these soils is chiefly due to the presence of comparatively large quantities of sodium

carbonate and sodium bicarbonate. The soil of the area is a heavy clay. A crop of paddy is generally raised under irrigation. Owing to the baneful effects of the black alkali in the soil the crop fails in patches and the yield obtained is extremely low, often being next to nothing. Experiments conducted both in the laboratory and in the field on the application of elemental sulphur to the soil at the rate of $\frac{1}{2}$ ton per acre have given very encouraging results. The initial alkalinity of the soil in the field was reduced by about 75% in the plots treated with sulphur during the course of three months, and the crop yield obtained from the experimental plots was more than double that of the plots not treated with sulphur. The experiment is being continued.

50. Studies on soil *Actinomyces*.

M. GANESHA RAO, ROLAND V. NORRIS and V.
SUBRAHMANYAN, Bangalore.

The *Actinomyces* have been noted to occur almost exclusively in the form of conidia in normal soil. A plate method has been developed for the accurate counting of the organisms. The distribution of the different species in the soil and their respective response to soil conditions and treatment have been studied.

BACTERIOLOGY.

51. On the disappearance of the colonies appearing on certain media used for bacterial and fungal counts.

V. SUBRAHMANYAN, Bangalore.

Many of the colonies appearing early on soil extract agar, casein agar, and such like media used for the counting of soil organisms were seen to disappear on further incubation of the plates. The physiological conditions attending their transformation have been studied.

52. Experiments on the preparation of organic manure.

GILBERT J. FOWLER, H. S. CHATURVEDI, R. N. JOHORI and
S. N. CHATTERJI, Cawnpore.

Experiments have been carried on at the Harcourt Butler Technological Institute, Cawnpore, for some years with the object of systematically investigating the suitability of various materials available for the preparation of organic manures, and of reducing the time requisite for the fermentation process.

Among the materials investigated may be mentioned some ten varieties of local weeds, banana stems, lawn grass, sann hemp and town refuse.

The necessary fermentation organisms were obtained from either cow dung, cow's urine or nightsoil, the last mentioned inoculant always producing the most active fermentation.

Rege's results were confirmed that fungi play an important part in the fermentation process, and that materials containing a high percentage of lignin cannot be rapidly fermented.

The fermentation was facilitated by passing the materials through a chaff cutter prior to fermentation. A vigorously fermenting mass or "activator" is built up in the first instance, to which small quantities of less completely fermented material are systematically added and thoroughly mixed. Finally the fermentation is completed anaerobically in pits, insect larvae being thus practically eliminated.

53. On the utilisation of waste vegetation—Part I, *Lantana camara* L.

ROLAND V. NORRIS, V. SUBRAHMANYAN and Co-WORKERS, Bangalore.

Analyses of the different parts of this natural exotic which covers a large part of the Deccan plateau have been made in order to study the possibilities of its utilisation as a green manure and as a raw material for the manufacture of industrial alcohol.

54. The effect of sulphur oxidation in activated sludge.
Part II—Influence of ammonification and nitrification.

C. V. RAMASWAMI AYYAR, Bangalore.

The changes in the various forms of nitrogen present in activated sludge especially the free and saline ammonia, and nitric nitrogen have been followed and the influence of sulphur and phosphate examined. The nature of the results indicates that there is an acceleration of the ammonification process but a complete inhibition in nitrification with the progressive rise in acidity.

55. A comparative study of the germicidal efficiency of E. C. and formaline on bacterial spores.

C. S. RAM AYYER, Pusa.

The efficiencies of electrolytic chlorogen (E.C.) and formaline in destroying spores of some soil organisms have been compared by a modification of the Rideal-Walker method. E.C. (dilution of 1 in 1,000) kills the spores of *B. mycoides* and *B. subtilis*, when the periods of contact are 30 and 90 minutes respectively. Formaline effects this in 5 and 15 minutes, but only in a strength of 1 in 10. Higher dilutions of formaline do not effect complete destruction of spores even after longer periods of contact.

In the case of formaline a definite concentration is necessary to kill the spores, whilst the time of contact is more important in the case of E.C. A probable explanation for this difference is suggested. Formaline acts by coagulating the albumen of the protoplasm. To effect this a definite concentration is necessary. E.C. effects the destruction of the protoplasm by nascent chlorine which is slowly liberated on dilution. Hence the period of contact is more important in this case.

The spore coat of *B. subtilis* being more refractory than that of *B. mycoides* a longer contact period of both disinfectants is necessary to effect complete destruction of the spores of the former.

56. Studies in vegetable rennet.

RAMJI NARAIN, Lyallpur.

Introduction and preliminary experiments. Preparation of the rennet. Action of preservatives on the rennet preservations. Effect of dilution on preservation. Influence of temperature. Reaction of the media. Dynamics of the rennet action.

ENTOMOLOGY.

57. A note on *Acacia catechu* as a lac host.

DOROTHY NORRIS and M. RANGASWAMI, Namkum.

The question of the suitability of *Acacia catechu* for the cultivation of lac is briefly discussed. Its rapid growth in comparison with other

superior lac hosts is shown and its capability to bear lac crops much earlier than the latter indicated. Yield figures are given to show that not only can the plant give a good crop when only three years old but also to point out that the resulting brood can produce better results on *kusum* than a pure *kusum* brood. It is also indicated that, in consideration not only of the yield of lac but also of its quality, the propagation of lac on this host is a successful proposition.

58. Investigation into the plant requirements of *Zizyphus jujuba* during growth and under lac cultivation.
Part I.

DOROTHY NORRIS, M. RANGASWAMI, M. VENUGOPALAN
and S. RANGANATHAN, Namkum.

Periodical analyses were made of *Zizyphus jujuba* for the purpose of finding out the distribution of inorganic constituents in the plant and their seasonal variations.

Total nitrogen in the leaves collected in January is less than that contained in leaves collected in August; also, when there is a decrease in the nitrogen of the leaves, there is an increase in either stems or roots or both, and *vice versa*.

Both total and inorganic phosphorus show a gradual fall as the plant grows. As regards the distribution, the leaves contain most and the roots least.

There is a gradual fall in the potash content as the plant grows. Seasonal variations are also observed in the three portions of the plant.

Variations in the amount of the calcium and magnesium are also shown and the probable connection of the variations of calcium with those of potash are indicated.

59. Resin and wax secretion by the lac insect on *Butea frondosa*.

M. VENUGOPALAN, Namkum.

The present investigation is an attempt to study the dynamic aspect of the output of lac by the lac insect.

The main constituents of lac secreted by the insect have been studied periodically from the time of its settlement up to the completion of its life cycle. The same aspect has been considered from the standpoint of seasonal differences and of the effect of the manurial treatment of the host. The period of accelerated output begins with the fertilisation and is sustained almost up to the time of reproduction. Manurial treatment of the host seems to increase lac production.

Though the duration of the life cycle of the insect is very different in the two seasons, the period of vigorous lac production seems to be practically the same in both cases. The delay in the maturity of the long season crop is, therefore, probably due mainly to the dormant condition of the host during part of the season and partly to the period of inactivity of the insect before the larval emergence.

60. *Componotus compressus* and the lac insect and its enemies.

P. S. NEGI, N. P. MISRA and S. N. GUPTA, Namkum.

The paper deals with the general description of the ant, its behaviour towards an intruder, the lac insect and the enemies of the lac insect; choice of cattle; its usefulness to the lac insect and the injury it does to the lac insect.

61. The economics of Indian *Thysanoptera*.

T. V. RAMAKRISHNA, Coimbatore.

In India the economic role played by insects of the order Thysanoptera has not become so conspicuous as it is in some other parts of the world. The different kinds of Thrips affecting specific crops like wheat, oats, tobacco, fruits, cacao, onion, and hothouse plants in Europe, America, the West Indies and other tropical regions are established pests. No species has yet gained such prominence in this country. Neither Lefroy nor Fletcher, in their books on Indian insect pests, has recorded any *Thysanopterous* form as a definite pest.

Within the past few years, a few forms belonging to this group have begun to attract the serious attention of the cultivator and the economic entomologist. In this paper, in addition to brief notes on the forms which have almost attained the status of pests, a list is added of others which, though not found doing any appreciable harm at present, may assume pest proportions under favourable conditions in the future. The chief object of this paper is to invite the attention of farmers and economic entomologists to the present activities and the possible future potentialities of the members of this little known group of insects.

62. The mango hopper problem in South India.

Y. RAMACHANDRA RAO, Coimbatore.

Since 1912 the Entomological Section at Coimbatore has received reports of damage by the Mango hopper. In 1914-15, demonstrations of spraying were fairly successful in Salem and Chittoor. Similar demonstrations in 1917-18 in the Alamanda tract, Northern Circars were not effective. To ascertain the cause of this failure, the problem was taken up in 1922. A scheme of control was devised and tested for several years in the three principal tracts of this Presidency, *viz.* Vizagapatam, Chittoor and Salem—Coimbatore.

It was found that the alleged failure of spraying was due to the great complexity of factors. The mango crop in any year depends on the combined influences of (1) the rainfall during the previous monsoon, (2) the weather during the flowering time, (3) the varieties under cultivation, (4) the incidence of mildew, (5) the occurrence of the hopper pest and (6) the degree of fruit-fall. Since to the cultivator the only criterion of success is the size of the ultimate harvest, it is important that any scheme proposed should aim at controlling as many of these factors as possible.

During the last five years, the following scheme has been found effective: (1) a preliminary spraying with Bordeaux mixture at flowering time to check mildew, followed by further sprayings if needed, (2) a thorough spraying with Fish oil resin soap if the hopper has appeared, followed by one or more sprayings at weekly intervals, (3) when fruits have set, irrigation or inter-cultivation to conserve the soil moisture with the object of preventing a heavy fruitfall.

63. The influence of physical environmental factors on insect abundance.

M. AFZAL HUSAIN, Lyallpur.

Of the three factors which check the increase and spread of insects, *viz.*, limited food supply, enemies and adverse climatic conditions, the last is the most important. Very rarely an insect finds itself among environmental conditions which are in every way favourable for its increase and spread. On such rare occasions a species completely dominates the situation. Most insects, however, live just on the margin of their 'vital limits.' For every species, there is a different vital limit;

some species possess great plasticity and are able to withstand a wide range of climatic variations, while others are susceptible even to slight changes. It is due to environmental factors that out of over half a million species of insects known in India, so few are pests, and some are so localized.

In the Punjab the distribution of *Gastrallus indicus*, *Platyedra gossypiella* and *Trogoderma khapra* appears to be controlled by temperature and humidity. In some parts *P. gossypiella* is a serious pest of cotton, while in the adjoining localities it is rare. A study of this insect, which is so wide-spread, has revealed some interesting facts. It has been observed that the eggs do not hatch when exposed to a temperature above 37°C. In the light of this observation it has been possible to correlate the incidence and distribution of this pest with temperature. This of course is only one factor, there are others which must be studied before definite conclusions can be drawn.

64. Studies on the morphology and bionomics of *Empoasca devastans* Dist.

C. J. GEORGE, Coimbatore.

This paper deals with a Jassid, *Empoasca devastans*, an important pest of cotton in South India. In addition to notes on the life history and bionomics of the species, an apparatus is described which consists of a pair of abdominal apodemes with muscular attachments. The nature and position of the apparatus is strongly suggestive of a sound-producing organ. Though it was known that some Jassids are capable of producing sound, the method of producing the sound was not known. This apparatus was also noted in another Jassid.

65. Life history notes on *Lamprosema indicata* (Pyralidae) a caterpillar pest of chrysanthemums.

M. C. CHERIAN, Coimbatore.

The paper deals with the life history and habits of a caterpillar pest of chrysanthemums—*Lamprosema indicata*—an insect belonging to family Pyralidae. Spraying of a stomach poison, lead arsenate, has been found to be effective against this pest.

66. Mathematics in the service of agriculture.

JOHN MACLEAN, Bombay.

(a) Where the mathematician is necessary, and mathematics as ordinarily taught prove inadequate even for criticism:

Journal of Experimental Biology, V, 110.

(b) Where "realistic" order leads to confusion: *Annals of Applied Biology*, XV, 486.

(c) Choosing from marine biology a finer, perhaps a too fine mathematical tool: *Memoirs of the Department of Agriculture in India*, IX, 6, diagram opposite page 171.

(d) The quantitative presentation of a manifold phenomenon: *Bulletin of the Department of Agriculture*, Bombay, No. 154 of 1928

RURAL EDUCATION.

67. Scope of the discussion.

G. L. C. HOWARD, Indore.

During the last twenty years, a considerable amount of propaganda work in connection with the improvement of agriculture has been carried

on by the Agricultural Departments of India. This propaganda has been conducted mostly by direct methods *i.e.*, by demonstration farms, touring officers, seed depôts and so forth. It is now being realized, however, that the illiteracy of the rural population is not only a serious bar to progress but also prevents the cultivator from obtaining an adequate return from his present primitive methods. This discussion has been arranged so that agricultural workers, who are primarily concerned with the improvement of agriculture, the cultivator's profession, may exchange views with those who are trying to educate the cultivator's child for his future profession. The great developments in Indian agriculture, which are possible through the application of science, will make increased and increasing demands on the intelligence of the future cultivator. The education of the next generation should therefore fit it for possible developments.

The minimum standard in Indian rural education which agricultural workers would like to see is the following: (1) all cultivators should be able to read simple vernacular leaflets, (2) all should have sufficient grasp of simple arithmetic to follow the accounts of their co-operative societies and to be able to hold their own in the market. Villagers are at present at a great disadvantage when disposing of their produce especially when improved quality is in question, (3) the general intelligence of the cultivator should be awakened so that he may be prepared to consider changes in his methods and have the necessary persistence to *continue* these improved methods after they have been demonstrated to him. Sufficient reasoning powers to enable him to repair simple implements is also necessary.

Another item—secondary agricultural education—is of importance to the spread of new ideas. This is the education of the sons of the better class cultivators or small zemindars from whom the natural leaders of the country-side should arise.

It is hoped to elicit actual experience on the best methods of attaining these various objects. The discussion will therefore be divided into two parts.

I. *Primary Rural Education.*

The particular points which it is suggested should be considered are the following:—

(1) The best method of providing sufficient schools and sufficient teachers of the required standard, taking into consideration the large number of small villages which exist. This would include the question of central and branch schools, of transporting the children to some distance to a central school, of travelling teachers, seasonal schools, and so forth.

(2) The best methods of preventing the present waste of effort due to irregular attendance and of ensuring that the average child shall attend for four years, this being the minimum time necessary to attain literacy. Under this head could be included the question of compulsion by the State, by the Local Authority or by private bodies such as Co-operative Societies. The important point of securing the consent of the parents to forego the labour of the child by making the curriculum more attractive, or by educating the parents themselves, (adult education) should be included.

(3) Additions to the curriculum beyond reading, writing and arithmetic with the hope of awakening general intelligence. The question of nature study, agriculture and school gardens to be especially considered.

(4) The training of teachers suitable for village schools and the possibility of improving the status of the teachers in the village without imposing impossible financial burdens on the authorities concerned.

(5) The best method of obtaining local financial support for the schools and the division of the cost between the locality and the State.

II. *Secondary Agricultural Education.*

68. Primary rural education in Madras.

S. C. DANIEL, Madras.

69 Primary rural education.

J. JESUDAS, Martandam.

The training given to a pupil in a four-year primary course ought to enable him to live a better life in his village. The teaching must be related to the life of the pupils.

The present syllabus is defective in the following respects. It is too literary. The four-year course is too long. The children do not use what they learn. There is no outlet for the children's energy nor scope for development. The syllabus is not attractive or suitable.

The syllabus might be improved by the application of the project method and by the following adjuncts. School gardens should be attached to every rural school. Cottage industries suitable for children should be taught. Religious or moral training. Supervised play, physical training and recreation. Scouting adapted to rural conditions and needs. Annual exhibitions of handicrafts where children of different schools might exhibit articles of their own production.

Training of teachers. The success of the scheme will depend upon the training given to teachers. The teacher must be able to make the school a centre of light and learning. He must be trained to become a real community leader.

70. The supervision of rural education.

MASON OLCOTT, Vellore.

Supervision is urgently needed and would save large sums of money.

What does supervision involve? It is the teaching of teachers as a friend, not inspection or criticism as an outsider. It involves the development of the teacher's purpose, not coerced conformity to mechanical standards. Supervision involves patient guidance to teachers in thinking through hard problems, not the hasty pouring in of second-hand thoughts or easy solutions. Thus supervision is a life-giving process that changes habits of teaching, not a deadening procedure that changes words or appearances.

What is the place of the supervisor? It is to serve the teacher, not to be served by the teacher. The supervisor is also commissioned to deal with the welfare of the children. Therefore let him help the children and the communities in all phases of their life.

What laws of learning can be utilized in supervision? The law of exercise: we learn what we practice: we do not learn what we do not practice. The law of effect: we learn to follow the ways that bring success and satisfaction: we learn not to follow the ways that bring failure and annoyance. The law of readiness; readiness to act gives satisfaction in acting but unreadiness gives annoyance. The law of attendant learnings: we never learn just one thing at a time, always many things. The supervisor can utilize all these laws to make his work effective.

71. Rural primary education in Bengal.

J. M. SEN, Calcutta.

The progress of education in Bengal has been very slow during the last five years compared to that in some of the other provinces of India. The number of primary schools rose from 36,615 in 1921-1922 to 38,187 in 1926-27 and the number of pupils increased from 11,64,576 to 13,98,942 i.e.,

by 2,43,345, but very few of these remained for more than one year under instruction. The enormous preponderance of pupils in the lowest class reveals the wastage. In Bengal the greatest obstacle to progress in primary education is the persistence of the inefficient one-teacher school. Under the present system of voluntary education the pay of a primary teacher is not a living wage. The existing expenditure on primary education, low though it is in India as a whole, is deplorably low in Bengal. A mere introduction of free education for all primary pupils, however, will not benefit Bengal unless the boys are compelled to continue their studies for some years. Arrangements have been made for the opening of agricultural classes in three per cent. of the middle schools in Bengal. All the capital cost of farms and gardens (*e.g.*, for fencing, buildings, wells, bullocks, implements, etc.) for these schools is paid by Government on condition that the school authorities provide at least 5 acres of land for a farm and half an acre for a garden.

72. A suggestion for improving village primary schools.

B. N. SINHA, Sepaya.

India is an agricultural country. In order that the rural population may be able to appreciate and practice some of the modern agricultural improvements, an effort should be made to train the mind of the rural child to grasp elementary scientific truths. This can be attained without overstraining the child by introducing the cardinal facts regarding agriculture and sanitation into the vernacular text-books, in the form of instructive short stories. The primary school gardens used for nature study should at the same time be utilized by the teacher to demonstrate simple experiments. This innovation will not seriously affect the working of the existing primary school curriculum, yet at the end of the course, the boy will have gained a fair knowledge of both agriculture and sanitation. For children, night schools are impossible because a rural child should not be required to sacrifice his sleep for the sake of study. A text-book drawn up in accordance with the suggestions made above is in preparation.

73. Primary rural education—A suggestion.

Y. D. WAD, Indore.

Aim: To develop the reasoning powers and to promote literacy and thus to enable the rural population to profit by modern progress.

A four-year curriculum with not more than four text-books is sufficient. The curriculum should consist of practical lessons in the following:—General agricultural practices. Manual training. This can be provided from the daily requirements of the farm. Nature study in the school garden maintained by the boys. Sanitation through personal cleanliness and school upkeep. The three R's should be casually introduced during this course. Very little sedentary classroom teaching should be given. The boys should be trained by means of practical indoor and outdoor work.

Every school should be provided with a small farm (half an acre). The simple buildings and other fittings should be kept in repair by the boys and teachers.

Attendance at school should not interfere with the normal working hours of a village. One hour in the morning and two hours in the evening should be sufficient.

The opposition of the parents can be removed if (1) the advantages of improved methods are brought home to them, (2) they perceive that their illiteracy has deprived them of pecuniary advantages, (3) they are assured that attendance at school leaves their children free for farm work.

Regular attendance can be secured by (1) the distribution of prizes of useful articles, (2) a gift to the child of the product of his own work.

Rural education should be separated from urban both as regards control and finance.

74. Adult education.

J. JESUDAS, Martandam.

Any system of adult education must have a comprehensive programme aiming at the all-round development of the lives of the rural population. Rural uplift largely depends on the removal of illiteracy and ignorance.

The following scheme is proposed: Night schools where reading, writing and arithmetic are taught. Lantern lectures on health, sanitation, the evils of drink, how to control diseases, the advantages of co-operative efforts. Demonstration of cottage industries and of better methods of agriculture. Exhibitions, cattle and poultry shows. These are of great educational value. Libraries and reading rooms with simple books suitable for rural folk. Social gatherings with a view to removing communal bitterness and caste prejudices. Co-operative societies where the people can learn self-help and co-operative effort and be trained in group thinking. Entertainments—gramophones, cinema, *kalaksepams*. Games under proper supervision. General instruction—how a locomotive runs, how a telegraphic message is sent, the rights and duties of citizenship.

Educated men and women of the towns might pay occasional visits to the villagers to guide them in their efforts towards social and economic progress. Ladies with medical training might give lessons to women on the care of the pregnant mother and infant (cleanliness, regularity of feeding and so forth).

75. Adult education by means of practical demonstration.

M. L. SAXENA, Indore.

Even if all the schemes proposed for the improvement of primary and secondary education are adopted in the near future, some time must elapse before they affect the outlook of the cultivator. To bridge over this interval and to create sufficient interest among the parents to make these educational schemes successful a certain amount of adult education is desirable. This might take the form of simple demonstrations of improvements on the cultivator's own land. Simultaneously the unsanitary conditions of the villages might be improved. It is obviously impossible to supply sufficient staff from the agricultural department and it is suggested that all the revenue and judicial staff who work in the villages should undergo a course of training in agriculture and sanitation at some institution before appointment. This would enable them to give helpful suggestions to the villagers and bring new ideas into rural life. This idea is already being carried out in the Holkar State.

The utility of cinema and magic lantern demonstrations is open to criticism.

76. Adult education in Bengal.

J. M. SEN, Calcutta.

The paper deals with the question of the re-organization of adult schools in Bengal on the lines suggested by the Royal Agricultural Commission.

77. Agricultural bias classes in the Bombay Presidency.

K. A. KHSIRSAGAR, Nasik.

In this course emphasis is rightly laid on the three R's. Boys are only initiated into the subjects. The course is pre-vocational and as such is not as purely agricultural and comprehensive as that given in the Punjab.

The institution of V. F. Certificate (agriculture) in 1926:—This is equal in all respects to the ordinary V. F. Certificate and has removed the handicap felt by villagers. More than 150 students have passed the examination and most of them are waiting for admission into training institutions.

Organization:—Control has been transferred to the local authorities.

Text-books:—Some new books, written on modern methods, have been published recently in Marathi.

Teachers:—The educational department is trying to convert one of the present training institutions into a special institute for the training of the teachers required for these classes.

78. Note on agricultural education.

R. Y. HULKOTI, Poona.

Progress in agriculture by means of demonstration is very slow on account of economic and educational conditions. There must be a desire amongst agriculturists for improvement if a permanent effect is to be achieved and an efficient system of rural education is necessary. In the Poona Agricultural Conference of 1910 this point was emphasised. The Agricultural Department, therefore, made an experiment with the *Loni* type of school which is partly a continuation course in the three R's. Only an elementary agricultural course could be attempted, on account of the capacity of the boys, who took some time to adjust themselves to manual work involved. The high cost of the staff and equipment make the rapid extension of this scheme impossible. The new agricultural bias schools can be used to supplement the schools of the *Loni* type. In addition to the linking up of these two types of schools, suitable arrangements for adult education are essential. To minimise the present urban influence it seems desirable to introduce agriculture even into the high school course. Success depends on the workers who must have the spirit of self-sacrifice and social service. Mr. Brayne's scheme for rural development is worth a trial and should be adopted by the Development Associations of Bombay.

79. A scheme for secondary rural education.

Y. D. WAD, Indore.

Aim:—To infuse life into rural areas by creating local initiative and thus stabilise the progress at present brought about by outside agencies.

A specialised training should be given to a few intelligent boys selected from the sons of well-to-do farmers and from the best products of the primary rural schools.

A five year curriculum consisting of a junior course of two years and a senior course of three years duration is suggested.

Junior course:—Instruction in indigenous and improved methods of agricultural practice. General workshop practice. General education. Elementary biology, physical geography, animal physiology and hygiene. Simple arithmetic and land measurement.

Senior course:—Individual and corporate farm management. The use and repair of agricultural implements and simple machinery. The working of co-operative institutions. General elementary science.

Simple veterinary remedies. Elementary accounts. A fair knowledge of the working of local bodies and government departments concerned with rural matters.

One residential school should be allotted to each typical agricultural area. It should be situated near an experiment station. Efficient teaching and high class equipment are essential.

Finance:—Funds should be provided by grants from the Government and by grants from local bodies and private sources.

Administration:—This should be similar to that of institutions receiving grants-in-aid.

80. Rural education in the United Provinces.

S. S. ROYA, Bulandshahr.

There is complete system of Rural Education in the United Provinces, laid on very broad foundations. Training has been developed on original lines at Bulandshahr. Agricultural education of a very high order is given at the Agriculture College, Cawnpore. The vocational training at the Bulandshahr School of Agriculture includes a number of short courses specially adapted to rural conditions. It is highly appreciated by the public.

Section of Mathematics and Physics.

President :—PROF. S. N. BOSE, M.Sc.

Presidential Address.

TENDENCIES IN THE MODERN THEORETICAL PHYSICS.

The ultimate aim of Scientific inquiry is to arrive at a minimum number of hypotheses which will explain the maximum number of facts. The hypotheses should obviously not contradict one another. At the present moment, however, we see two contradictory theories, in the domain of Physics. On the one hand we have the classical theory based on the dynamical laws of Newton. On the other hand we have the Quantum theory first introduced by Planck, which has been differently formulated by different Scientists; while the Classical Theory explain satisfactorily all problems relating to motion and interaction of big masses as well as the problem of propagation of radiation, the Quantum Theory has succeeded with the help of a few principles in co-ordinating a large amount of experimental material accumulated in the various domains of spectroscopy, X-rays, etc. It has succeeded best in all problems dealing with the ultimate constitution of matter, or in problems dealing with the interaction of matter with radiant energy. As a result of work of the last twenty-five years, we seem to be much nearer to understanding the problem of matter. The periodic classification of Mendeljeff does not now appear as an unexplained riddle and the huge amount of spectroscopic material can now be classified and explained with the help of a few fairly simple principles. The task that faces the Physicists to-day is how best to harmonise the seeming discord of the two theories, which are at the present moment utilised to explain the physical phenomena. It is a difficult task, and the first step towards fulfilment will be to place in a clear light the differences that characterise them: for this purpose it is necessary to trace the history of the development of our physical ideas indicating the various points where fresh hypotheses had to be introduced before the next move towards progress could be made.

Theoretical Physics may be said to have begun its career as a Science with the formulation of the famous laws of motion by Newton. The mathematical formulation of this principle leads to a series of differential equations in which we equate certain quantities which depend upon the state and nature of the body under investigation with certain other quantities which we interpret as forces arising out of the

interaction of other bodies. The solution of these differential equations introduces a certain number of arbitrary constants which depend upon the initial state of the system investigated. These constants once known determine completely the subsequent history of the system under observation. Newton's original equations involved the use of the cartesian co-ordinate system, but very soon these equations were transformed into a form in which the arbitrary character of the co-ordinates was removed, and finally Hamilton and Jacobi introduced the characteristic function, which reduced the problem of solving the equations of dynamics to the solution of a single partial differential equation. Simultaneously, with the help of the concept of the Variational Calculus, we arrived at the celebrated Hamilton's Principle, by which the whole problem of dynamics was reduced to the problem of making a certain integral an extremum, within certain suitable limits.

The writing down of the set of differential equations, or of the single partial differential equation of Jacobi requires however the knowledge of the laws of interaction of various bodies on one another. The exact formulation of these laws seem therefore to be the immediate aim of the earlier classical Physicists. These laws once known allow us to apply to any problem the general dynamical methods, whereby the problems of Physics are reduced to problems of pure mathematics. In the laws of gravitation, in the law of Coloumb and of Ampere, we have some classical examples; in every case it is endeavoured to express the force in terms of the relative co-ordinates, and the velocities of the interacting masses.

The laws of dynamics were originally formulated to explain the motion of observable bodies. When with the progress of knowledge the discrete nature of the constitution of matter was evident, the natural endeavour has then been to extend to those ultimate particles (the atoms, protons, electrons), the same dynamical laws which have been so successfully applied to the study of big masses. As the aim of Physics is to explain the observed physical phenomena, in terms of the motion of the ultimate particles, a consistent application of the dynamical methods has been responsible for the whole structure of classical Physics.

Before the methods of classical dynamics could be applied important developments in two directions had to be made. The problem of specifying the law of interaction of the different particles, when we have to take account of the immense number of the constituent particles raised difficulties which were resolved and the problems made more amenable to analysis by the introduction of the conception of the Field. It was discovered that instead of basing the description of interaction on the various laws, (formulated on the action-at-a-distance basis), a much simpler and a better treatment could be obtained by the

introduction of certain auxiliary magnitudes—The scalar or the vector potential, or The Electric or Magnetic intensities. These quantities vary with the position in space, as well with time. The characteristic functions determining the field were found in the case of electro-magnetism to satisfy a certain linear set of partial differential equations, whereas the relation between the magnitudes introduced, and the reacting masses may be expressed by a certain type of equation of the second order. These auxiliary magnitudes thus came to be looked upon as having their seat in a hypothetical medium which was postulated to pervade all space, and the partial differential equations which connect them came to be looked upon as related in some way to the physical properties of the hypothetical medium, the Ether. By the introduction of the concept of energy and momentum density, the abstract conception of ether seemed to gain in substantial reality. This was further strengthened when it was shown that it was possible to bring the partial differential equations in line with the usual dynamical equations, in as much as they appeared to be deducible from the Hamilton's principle if certain quantities were identified with the potential and the kinetic energies of the medium. Thus we come to the classical conception of Ether, and the electro-magnetic equations of Maxwell which served as the starting point of the modern Electron-Physics. Gravitation, however, did not immediately fall in line with the other field theory, until the formulation of the generalised Relativity-Principle by Einstein. Of this we shall have occasion to speak later on.

There was however another difficulty which stood in the way of immediate application of the classical methods to the problems of Physics. The dynamical laws seem at first applicable to the motion of the ultimate particles, which themselves however always escape direct observation. What we observe is to be looked upon as the resultant of a large number of elementary events; and the measurable microscopically sensible magnitudes cannot also be regarded as determining uniquely the component microscopic elements. Thus, from the classical standpoint, the necessary magnitudes for uniquely characterising the state of the system remain largely undetermined, and the Physical laws connecting observable things cannot be regarded as immediately deducible from the dynamical laws, at any rate without the introduction of further hypotheses. The method of statistical mechanics was developed to tackle this fundamental difficulty. The earlier method consisted in regarding the ultimate particles as practically independent systems. Each system is characterised by certain values of co-ordinates and momenta. Under their mutual interaction, Space and momenta coordinates of the individual systems are supposed to vary within certain limits. The actual physically observable magnitudes are determined by the distribution of the systems among the

different physically possible states. Mathematically this distribution is visualised by the distribution of the representative points of the individual systems in a phase space, which is supposed to be decomposed into a certain number of elementary phase-cells. The actual position of any particular representative point inside the phase-cell, is supposed to have no effect on the value of the phenomenologically observable magnitudes. The equilibrium-state of a physical system can thus be related to a particular distribution of the representative points in the phase cells which occurs most frequently, or remain longest during the period of observation. By this way the important physical idea of entropy can be connected with the probability of distribution in the Phase-Space, and important Thermodynamical laws can be looked upon as certain statistical laws which are necessary consequences of the very large number of individual components. When the results of classical dynamics are combined with this concept of statistics, we get certain very general laws, regarding the partition of energy. Though at first, these results seemed to agree with the facts observed, subsequent and more exact experiments have shown them to be erroneous.

I have already referred to the equations of classical mechanics which determine the motion of a material particle, as well as the field equations, which connect the vector magnitudes serving to describe the electro-dynamical field. Though it was attempted to bring these equations in line with the dynamical laws by showing that they also can be deduced from Hamilton's Principle, a fundamental difference between the two sets of equations was clearly brought out during the early part of this century. The dynamical equations of Newton possess an invariant group of transformation, the Galilean Group, which expresses the equivalence of all inertial systems as frames of reference for the description of motion. The field equations of Maxwell however, have a different invariant group, the Lorentzian group. The space and time co-ordinates enter symmetrically into these equations, or rather the space-time symmetry can be brought out by introducing after Minkowski an imaginary time ict , as the fourth co-ordinate. The Lorentzian group of transformation can be represented by a rotation of axes in a four dimensional orthogonal space, which leaves the invariant distance unaltered. By extending the conception of vector quantities of the usual three dimensional space to four dimensions, the field equations can be given an invariant form. The recognition of this formal equivalence of the time and space co-ordinates ushers in the ideas of relativity. This equivalence now-a-days is regarded as axiomatic, and furnishes a test which all physical laws have to satisfy in order to be exact. By generalising this conception further, and by giving up the condition of orthogonality Einstein was able to present

a field theory of gravitation. The two different field theories have however remained essentially distinct though attempts have repeatedly been made to fuse them into one single unitary theory.

I have now indicated to you the principal steps by which the classical theory arrived from its first elementary stage to the present developed state. I shall now tell you of the difficulties that arose successively and which led to the formulation of the quantum theory. The conceptions of energy and momentum have been early deduced from the dynamical laws and have played very important roles in the subsequent development of the Science. For example the Hamilton-Jacobi differential equation requires for the mathematical expression the writing down of total energy of the system in terms of the momenta, whereas the integrand in the Hamilton's Principle is the difference between the potential and the kinetic energy of the system. The introduction of the concept of energy seems necessary for the applicability of the general dynamical laws, and we have seen how the field equations can be made compatible with the dynamical laws by interpreting a certain magnitude as the energy-density of Ether. As a necessary corollary to the equations however it follows that there will be a continuous interchange of energy between the ultimate particles composing matter and the surrounding radiation field. The principle of equipartition of energy which follows as a necessary consequence of the idea, leads us however to entirely wrong results when applied to the problem of equilibrium of radiation-field with matter. In order to explain the distribution of energy in the black-body radiation spectrum, as well as to explain the problem of generation of radiation we have been compelled to make certain assumptions regarding the constitution of the radiation-field, and about the equilibrium states of material particles, which directly contradict our classical ideas. This has led to the introduction of the Quantum theory in Physics. The energy in the monochromatic radiation field, has to be assumed to exist in definite quanta. The study of the constitution of matter has led us to the conception of the atom as a comparatively stable structure built out of the nucleus and electrons. These electrons according to the earlier formulation of the quantain theory are to be supposed as rotating in certain characteristic orbits; whereas such a constitution on the classical theory will necessarily continually radiate and lose energy, we have to assume here that such a structure keeps generally intact its energy-content and also that there are a series of discrete radiation-free states characterised by a discrete series of values of the energy content. An interchange of energy can only take place, when the atomic system passes from one distinct state to another resulting in an emission or an absorption of radiation. The passage of the atom from a higher energy state to a lower is

associated with an emission of a monochromatic radiation whose frequency is given by the relation

$$W - W' = hn.$$

where W , and W' are the characteristic energies of the two states.

Modern development of spectroscopy seems to indicate that the state of a system may be defined by the introduction of certain sets of quanta members, each set being associated with a definite constituent electron of the atomic system. No two electrons of the atomic system may have the same group of the quanta-numbers, and the successive building up of the different atoms may be looked upon as a gradual increase in the number of electrons in the outer *orbit*, each electron coming to occupy a place characterised by a different group of quanta numbers.

These few principles which are so contradictory to the ideas of classical dynamics have proved to be invaluable in the development of modern Physics. To them we owe the scientific classification of the spectroscopic terms, explanation of the Periodic classification, etc., etc. The direct and simple way in which the different problems, which have long baffled the attempt of classical physics, find their explanations in the new theory shows that it contains a large element of truth, and the most important problem of the present time is to find a way of reconciling the two theories. It has become evident also that no one theory will be able to entirely replace the other. For example the conception of the field, which has been developed originally from the classical standpoint, seems to contain also a great element of truth. The large mass of experimental material connected with the problem of propagation of radiation, seems to find in the field theory a very simple and direct explanation, which appear so difficult to explain from the Quantum-theoretical standpoint.

The solution of the dilemma seems to lie in suitably uniting the field and the quanta-theories, which will ultimately form a more general theory of which the two theories may then be regarded as limiting cases. We have in recent years already some indications of tentative attempts in the same direction. One may attempt to visualise the radiation-field as simply determining the interaction of the different particles and give up the classical concept of energy and momentum-density in Ether. Consistent with our ideas of the quantum theory we may regard that the energy in the field is only discretely distributed throughout the space, (somewhat after the ideas of J. J. Thomson). The motion of these quantas of energy may be supposed to be guided as it were by the field, and it may be supposed to take place along the direction of the Poynting

Vector. The same field which guides the motion of the quanta may be also supposed to control the motion of the electrons in the different orbits. The nature of the field itself should be determined by some equations depending upon the distribution of the charges. Such a field theory will have as its task the explanation not only of the fundamental relation $E=h\nu$, but also of the occurrence of the discrete quanta-states and the different quanta-members.

That the idea of discrete energy-states is not inconsistent with a continuous field-theory seems to follow from the recent developments of the wave-mechanics (Schrodinger, Dirac). In the classical theory the impossibility of the existence of stationary electron-orbits follows from the result that an accelerated electron gives rise according to it to an electro-magnetic field such that the surface integral of the Poynting Vector at a great distance does not vanish. The result is interpreted as indicating a continuous loss of energy from the moving electron which makes stationary orbits impossible. One can think however, that if there are other electrons present the resultant field may be such that the electron may in the average gain as much energy from the surrounding field as it loses by radiation, or in other words the resultant electro-magnetic field due to all the moving electrons may be such that the integral of the Poynting-Vector vanishes. Such a hypothetical solution of the field-equations which make the field vanish at infinity may be thus likened to a stationary vibration rather than to a divergent wave-train. It is clear, however, that the distribution of the charges will have to be suitably made and their motions definitely related in phase with one another in order that such a thing may be possible. The electro-magnetic field may then be supposed to be in resonance after de Broglie. What Schrodinger succeeds in establishing may be likened to finding exactly such a law of distribution of charges. The quanta conditions then may be fittingly compared with the resonance conditions. Dirac seems to have succeeded in deducing a set of four linear partial differential equations which correspond to facts more closely. The four functions or rather eight of them give us the distribution of the hypothetical charges and currents in the electro-magnetic field necessary to establish resonance-conditions. The field itself in these two theories determines also the distribution or rather the statistically equivalent distribution (in space as well as in velocity) of the charges in the field.

One may hope that the final solution of problem may be found and the proper set of equations which will determine the radiation-less field may be determined with the help of the ideas of the generalised relativity theory. If an unitary field theory which could explain gravitation and electro-magnetism could be found, one would hope to obtain thereby not only

the solution of the quanta-problem, but perhaps also of a more fundamental problem, the relation of charge with gravitational mass, and explanation of the difference in mass of the proton and the electron.

Section of Mathematics and Physics.

Abstracts.

1. Spectra of metallic arcs in atmospheres of foreign gases.

B. VENKATESACHAR and L. SIBAIYA, Bangalore.

It was found by one of us (*Proc. Roy. Soc. A*, vol. 117, 1927.) that the introduction of air brought out the higher members of series lines in the radiation from a mercury vapour lamp. Other instances of the influence of the admixture of gases on the character of spectra are known; for instance, Merton and Johnson (*Roy. Soc. Proc.*, vol. 108, p. 343, 1925) have shown that lines of neutral carbon are excited when a mild condensed discharge is passed through helium containing a trace of CO or CO₂. In the present work a mercury arc with the anode cooled by a current of water was produced in a pyrex tube with a large dead space and the purified foreign gas was slowly let in, the pressure measured by a manometer ranging from 1 mm to 60 mm in the case of CO₂. Other gases hitherto used by us are Nitrogen, Hydrogen, and water-vapour. The following is a summary of the principal results obtained when the admixed gas was CO₂.

(1) All series show more higher members as the pressure is increased upto 20 mm, $2^3P_2-2^3D$ being distinctly visible on the plate. The diameter of the orbit is in this case 5.4×10^{-6} cm about and the mean distance between the atoms is 1.37×10^{-6} cm. The intensity of a line relative to the next higher member diminishes upto 20 mm and then rises. The sharpness of the lines markedly increases when the excess of mercury vapour is removed from the arc by cooling it, the pressure inside remaining as high as 60 mm.

(2) Forbidden lines :—Lines violating the azimuthal quantum number rule markedly gain in relative intensity as the pressure increases; at a pressure of 60 mm on removing the mercury vapour by cooling the arc these lines fall in relative intensity.

(3) Spark lines (presumably all of Hg II) behave in an interesting manner; some weak lines become strong with increase of pressure while lines previously strong become weak.

(4) The continuous spectrum almost entirely disappears when the arc is cooled, the arc spectrum standing out prominently on a clear background, the pressure inside being 60 mm.

These results are theoretically discussed.

The introduction of water-vapour has the remarkable effect of obliterating the higher members and of enhancing the continuous background.

2. The extension of the irregular doublet law to complex spectra.

M. N. SAHA and P. K. KICHLU, Allahabad.

It has been shown that the irregular doublet law, or the law of arithmetic progression, holds good also in the complicated spectra of elements.

3. On the method of horizontal comparison in the location of spectra of elements.

M. N. SAHA and K. MAJUMDAR, Allahabad.

A new method has been developed for locating the spectra of successive elements forming a group having the outer constitution $(x+1)p$, x varying from 0 to 6 (eg. B, C, N, \dots to Ne ; Al, Si, P, \dots to K ; $Si, ^+P, ^+S, \dots$ to $Ca; ^+$ etc.). The transition considered is $xps \leftarrow xpp$.

4. On the method of horizontal comparison in the location of spectra of elements (II).

K. MAJUMDAR, Allahabad.

Method used in the previous paper has been applied to locate the lines due to the transition $xpp \leftarrow xpd$. The law is found to hold good in this case also.

5. The spectrum of doubly ionised calcium.

K. MAJUMDAR, Allahabad.

The method of the irregular doublet law and that of horizontal comparison have been used in locating the spectrum of Ca^{++} . The lines are obtained from the data given by Anderson (*Astro. Jour.*, Vol. 59, p. 76), who, by using condensed discharge in vacuum, obtained a large number of lines. A number of lines has been analysed and attributed to the transition $5M_2 (N_1 \leftarrow N_2)$. The fundamental difference is $3P, -^+P, = 3766$. The correctness of the analysis is justified by the fact that this is also approximately the difference between the two strongest lines, $\lambda 403.8$ and $\lambda 410.1$, obtained by Millikan and Bowen in their hot spark spectrum of Ca in the extreme ultra-violet. These must be the $'S_0 - ^+P_1, ^3P$, lines due to the transition $5M_2 (M_2 \leftarrow N_1)$.

The ionisation potential of Ca^{++} comes out to be approximately 52 volts.

6. On the infra-red spectrum of chlorine.

K. MAJUMDAR, Allahabad.

The infra-red spectrum of Chlorine has been photographed between $\lambda 7500$ and $\lambda 9000$ using neocyanine plates and lines belonging to the transition $4M_2 (N_1 \leftarrow N_2)$ have been located and classified.

7. On the spectrum of doubly ionised chlorine.

K. MAJUMDAR and S. C. DEB, Allahabad.

Thirty lines of Cl^{++} have been classified in addition to those previously classified by Bowen (*Phy. Rev.*, Vol. 31, p. 35). The lines are from the data by Bloch (*Ann. de Physique*, Vol. 8 p. 379). The lines classified are attributed as arising from the transitions $2M_2 (M_3 \leftarrow N_2 \leftarrow N_3)$.

8. On the spectrum of carbon.

D. S. JOG, Allahabad.

The heavy arc spectrum of carbon was photographed and about 70 new lines were obtained chiefly in the region $\lambda 1931$ to 2000. Some of these lines were classified and out of them the intercombination lines of the Singlet and Triplet systems of $2L_2 \leftarrow L_2M_1$ were obtained. According

to Saha's theory some Coronium line may be due to the forbidden transition $3P_1-1\bar{S}_0$; no line could be accounted for by the forbidden transition $3P_1-1\bar{S}_0$ in this case. Some of the old lines are also classified, and interpreted as being due to the inner-transition $2L_2 \leftarrow L_1$ $3L_2$.

9. First spark spectrum of krypton.

P. K. KICHLU, Patna.

This paper is in continuation of the work presented to this Congress last year. It has since been found possible, with the help of the data in the extreme Schumann region, to complete the term-scheme in the spectrum of ionised krypton. The lowest states are $2P$ terms originating from an electronic configuration of $5N_2$, and have a separation of 5371 wave number units; the corresponding separations in Ne^+ and Ar^+ being 780 and 1431 respectively. These $2P$ terms combine with a set of terms $4P$, $2\bar{P}$, $2D$ and $2S$ coming from $4N_2$ O_1 , and give rise to a group of resonance lines of Kr^+ between λ 783 to 911 \AA . Other levels obtained are derived from $4N_2$ O_2 , $4N_2$ O_3 and $4N_2$ P_1 . The fundamental doublet terms of the combination $5N_2$ form a Rydberg sequence with those of $4N_2$ O_2 , and in this way the ionisation potential has been calculated as 26.5 volts.

10. Infra red radiations of active nitrogen.

P. K. KICHLU and D. P. ACHARYA, Patna.

The present day theories of active nitrogen describe it as simply atomic nitrogen, by analogy with active hydrogen, which is now believed to be atomic. Since active hydrogen shows Balmer lines strongly, the experiments described in the paper were undertaken to find whether active nitrogen also gives the corresponding lines which lie at about λ 8200. The spectrum of active nitrogen has been photographed upto λ 8900, but no lines due to atomic nitrogen have been observed. It has been found that the first positive group of nitrogen bands, which was photographed by Fowler and Rayleigh in the visible region in the spectrum of active nitrogen, is continued right upto the maximum red sensitivity of our plates, i.e., λ 8900.

11. Analysis of the singly ionised spectrum of sulphur (S^+).

D. K. BHATTACHARJYA, Patna.

The spectrum of ionised sulphur has been studied under variety of conditions of excitations in a discharge tube of special construction in which vapour of pure sulphur was continuously circulating. This method is particularly suitable for the removal of impurity lines and for the adjustment of the pressure in the tube.

The spectrum consists of a series of quartet and doublet terms of which a number have been isolated. The following table gives the electronic configurations from which the term systems in S^+ are derived along with the predicted and observed terms:—

Electronic configurations.	Predicted terms.	Terms observed.
3M_3	$^4S_2 \ ^2D_{2,3} \ ^2P_{1,2}$	
2M_2N_1	$^4P_{1,2,3} \ ^2P_{1,2} \ ^2D_{2,3} \ ^2S_1$	$^4P_{1,2,3} \ ^2P_{1,2} \ ^2D_{2,3}$
2M_2N_2	$^4D_{1,2,3,4} \ ^4P_{1,2,3} \ ^4S_2 \ ^2D_{2,3}$ $\quad \quad \quad \ ^2P_{1,2} \quad \quad \quad \ ^2S_1$	$^4D_{1,2,3,4} \ ^4P_{1,2,3} \ ^4S_2 \ ^2D_{2,3}$ $\quad \quad \quad \quad \quad \quad \quad \ ^2P_{1,2}$
2M_2N_3	$^4F_{2,3,4,5} \ ^4D_{1,2,3,4} \ ^4P_{1,2,3}$ $\quad \quad \quad \ ^2F_{3,4} \quad \quad \quad \ ^2D_{2,3} \quad \quad \quad \ ^2P_{1,2}$	$^4F_{2,3,4,5} \ ^4D_{1,2,3,4} \ ^4P_{1,2,3}$

The spectrum is well represented in some hot stars, to which attention was drawn long ago by Sir Norman Lockyer.

Inter combination lines between doublets and quartets have also been obtained.

12. Series in the spectra of Germanium.

A. L. NARAYAN and K. K. RAO, Vizianagram.

Photographs of the spark spectrum of Ge have been taken under a variety of experimental conditions and the spark lines have been assigned to the various stages of ionisation by the usual method. The wave lengths of the lines above 2000 Å have been measured by the writers while for smaller wave lengths the existing data are made use of.

Ge II.—This spectrum has been almost completely analysed and it has been found that the spectrum showed the existence of all the chief regular doublet due to the configuration (s^2p^1) and of a^2D , a^2P and probably of $a^4\bar{P}$ of the configuration (s^1p^2). By assuming $12F$ to be equal to 23320 cm^{-1} the values of the several terms are calculated through a connected system of members. The largest term $12P_1=128635 \text{ cm}^{-1}$ giving the second ionisation potential of 15.88 volts while the resonance potential is 7.7 volts corresponding to

$$\lambda^{-1} 1602.6 (12P_1-12S_1)$$

Ge III.—Theoretical considerations indicate that this spectrum consists of triplets and singlets.

Observation shows the presence of prominent triplets with intervals ($2^3P_1-2^3P_2=459$, and $2^3P_0-2^3P_1=169$ which are believed to belong to the secondary series of the spectrum. All the prominent multiplets have been located and the values of the terms found by assuming $1^3F_4=63000 \text{ cm}^{-1}$. The largest term 1^1S_0 is 268717 cm^{-1} and leads to the third ionisation potential of 33.17 volts.

Ge IV.—The chief members of the primary series of this spectrum have already been located by Caroll. In the present work the classification has been extended to the region of long wave lengths. Sets of pairs with frequency difference 936.5 are found to form Rydberg sequences converging to a common limit. The analysis has been greatly facilitated by the knowledge of the spectrum of Ga III from the previous work of one of the writers.

Ge V.—On eliminating all the lines that have been classified into Ge II, Ge III and Ge IV it has been found that many of the prominent remaining lines in Caroll's vacuum grating data could be classified into

fundamental multiplets belonging to Ge V. Thus the levels corresponding to the configurations (d^3s^1) and (d^3p^1) have been identified.

An interesting point in connection with the spectrum of Germanium is that the spectra of the metal taken under different conditions of excitation contain a group of lines which exhibit the characteristic behaviour of appearing more and more prominently when the self inductance in the circuit is increased.

Further study of these and similar groups in other spectra is in progress.

13. Series regularities in the spectra of Tl II, Pb III and Bi IV

A. L. NARAYAN, P. PATTABHIRAMIAH and RAO, Vizianagram.

Continuing the work in this laboratory on the spectra of Ga II and Ge III and In II and Sn III, a study of the series regularities in the spectra of Tl II, Pb III, and Bi IV is taken up. On the basis of Cardl's measurements in the vacuum grating region and of those of the authors in the region above $\lambda 2100$, it has been possible to identify all the important multiplets in these spectra. The experimental method of separating the lines due to the various stages of ionisation of the element in each case is the same as that adopted by the authors previously. The term values are estimated in each case by assuming 1^3F_4 through a connected system of members. It is interesting to note that in these spectra the F-term is partially inverted, $1^3F_2 - 1^3F_3$ being negative.

14. Series in the spectra of singly ionised and doubly ionised arsenic.

P. PATTABHIRAMIAH and D. BHAGAVANLU, Vizianagram.

The application of Hund's theory of spectra to the prediction of the characteristic terms of the spectrum of As II suggests that the most easily excitable lines of the spectrum should form a $1^3P - 1^3\bar{P}$ group. While this lies in the vacuum grating region, the member $1^3\bar{P} - 2^3P$ is to be expected in the visible region. The most important levels to be expected in this spectrum are

$$\begin{array}{ccc} 1^3P & 1^1\bar{D} & 1^1\bar{S} \\ 1^3\bar{P} & 1^1\bar{P} & \\ + 1^3\bar{D} & 2^3P & 1^3\bar{S}, \text{ etc.} \end{array}$$

important multiplets that fall in the visible and near ultra-violet regions are identified.

The examination of the spectrum of As has shown the existence of some prominent doublets belonging to the doubly-ionised stage. It has been found that the frequency difference 723 cm^{-1} of these doublets recurs. As a result of this analysis all the important regular doublet terms of the spectrum together with the terms a^4P , a^2D and $a^2\bar{P}$ have been identified and the terms values are found.

15. Hydrogen atoms in parallel and crossed electric and magnetic fields.

N. R. SEN, Calcutta.

The equations of Dirac and Darwin are adequate to determine the proper number and values of energy levels in an atom placed in a uniform

magnetic field. R. Schlapp has shown that they also give the Stark effect in a weak electric field. The equations were so designed as to explain the so-called "duplexity" phenomena by giving the proper number of energy-levels known from spectroscopic data. The case of crossed fields is one in which the former quantum theory based on classical mechanics is known to lead to serious contradictions which according to Pauli can be avoided only by some fundamental changes in our quantum conceptions. The Dirac Darwin equations involve no difficulty in principle in their application to simultaneous electric and magnetic fields. The successful explanation of the complicated phenomena in crossed fields will lend strong additional support to the new theory.

Two extreme cases have been worked out namely when one of the fields is strong compared to the other while both are strong enough to justify the neglect of the relativity effect. In case of parallel fields it is shown that the introduction of a weak magnetic field ends the state of degeneration which partly exists in an electric field by splitting up all the coincident energy levels. The parallel polarised lines remain unaltered while every unpolarised line splits up into two lines perpendicularly polarised as in Lorentz triplet only the middle line is absent. A selection principle exists for the combination of different levels. The calculations for crossed fields are extremely complicated. The case of $H\alpha$ has been worked out for strong magnetic field. The spectrum is unsymmetrical about the central line with regard to position, intensity and polarisation. There are lines which are elliptically polarised. No selection principle in the older sense exists since the quantum numbers lose their significance.

16. New bands in the secondary spectrum of hydrogen. Part II.

D. B. DEODHAR, Lucknow.

In this paper the author deals with a system of seven new bands discovered in the blue region of the spectrum. These bands are very similar to those in the yellow region which are published in the *Philosophical Magazine* (September 1923).

From the values of the moment of inertia and their successive decrease from high value to a low value similar to those in the previous paper, it becomes evident that the present system of bands is also due to an excited hydrogen molecule and that the groups are related. The term values and other details are given in the paper.

17. Some optical properties of active nitrogen.

S. P. VENKATESWARAN, Madras.

A study of the afterglow observed in a mixture of oxygen and nitrogen was made by the method of interrupted illumination using an induction coil and mercury break fitted with a disc. A continuous spectrum in the yellow green portion and lines on the lower wavelength side and a few in the red portion of the spectrum were observed. After the discovery by Professor C. V. Raman of the new radiation, it was suggested that a study of the scattering properties of active nitrogen will be of interest, since excited molecules may be expected to be present in large quantities. The spectrum of the scattered radiation by active nitrogen gave in addition to the mercury and the glow lines, also lines at 5904, 5680, 5560, 5361, 5269 and 5169. When analysed 5904, 5560 and 5269 gave a number difference of 670, while 5680 and 5361 gave a difference of 340 and 5169 gave 1040. An experiment was also conducted on molecular scattering with an exposure of 120 hours with Hilger's E_2 quartz spectrograph and in the scattered spectrum 4358 had a companion

line with wave number difference of 180, 4047 had one with 150 and 3650 had a line with a wave number difference of 140. Further investigation is proceeding.

18. The Schumann absorption bands and the electronic levels of the oxygen molecule.

A. S. GANESAN.

The paper deals with the structure of the absorption bands of oxygen in the region λ 1860 to λ 1970, obtained with a large dispersion quartz spectrograph. Formulas are given for the structure of these bands and the band-heads. The results are found to be in accordance with those known for the other bands in the system. Theoretical interpretation shows that alternate lines must be supposed to be missing and that each band contains only the *P* and *R* branches. The structure of these bands corresponds to a $^3S \rightarrow ^3S$ transition.

19. The Raman effect in alcohols.

S. VENKATESWARAN.

The paper gives the results of a study of the Raman effect in water and some alcohols. Water gives a prominent band corresponding to 3.0μ which is feeble in methyl and ethyl alcohols. Amyl alcohol gives a continuous spectrum in addition to the Raman lines, probably arising from its higher viscosity. The polarisation of the scattered radiations in amyl alcohol has been studied spectroscopically and it is found that the modified radiations are also polarised. The degree of polarisation of the different modified lines is found to be different, but for the same frequency difference the corresponding modified lines are polarised to the same extent. Allyl alcohol shows a characteristic doublet formation of the modified lines which may be due to the presence of the double linkage. The characteristic infra-red wave-lengths thus obtained are shown below (in μ).

Water:— 3.0 .

Methyl alcohol:—feeble band 3.0 , 3.402 , 3.53 , 6.82 , 9.70 .

Ethyl alcohol:—feeble band 3.0 , 3.363 , 3.41 , 3.48 , 3.55 , 6.84 , 7.86 , 8.58 , 11.31 .

Amyl alcohol:— 3.38 , 3.47 , 6.86 , 7.47 , 8.99 , 9.88 , 10.47 , 12.04 , 13.03 , 22.22 , 29.32 .

Allyl alcohol:— 3.25 , 3.32 , 6.06 , 6.81 , 7.04 , 7.52 , 7.76 , 8.66 , 9.05 , 9.70 , 10.03 , 10.97 , 15.57 , 18.14 , 22.9 .

20. The Raman spectra of sulphuric acid and sulphates.

S. K. MUKHERJEE and P. N. SEN GUPTA, Dacca.

The Raman spectra of concentrated sulphuric acid sodium sulphate, magnesium sulphate, copper sulphate, aluminium sulphate and benzene sulphonic acid have been studied by a Hilger's constant deviation spectrograph and a mercury arc. All these except copper sulphate show modified lines. In sulphuric acid there are 5 modified lines on a continuous back ground at 4537.9 , 4464.0 , excited by 4358.3 ; and 4432.5 , 4202.7 , 4140.2 excited by 4046.56 . The calculated infra red absorption bands lie at 11.01μ , 18.4μ , 4.68μ , 10.96μ , 17.91μ , whereas the Coblentz's values for the absorption edges as determined from reflection are at 8.6μ , 9.55μ , 10.42μ and 11.35μ which show that the calculated values at 11.01μ and 10.96μ corresponds to Coblentz's value at 11.35μ , while the others 18.1μ , 4.68μ , 17.91μ , together with Coblentz's value at 9.55μ

seem to show that 18.1μ is the fundamental and 9.55μ , 4.68μ are the over tones.

In the case of sulphates the modified lines lie at 4552.2 excited by 4358.3 and 4213.7 excited by 4046.56 . The calculated absorption band lies at 10.2μ whereas the Coblentz's value for sulphates lie at 9.23μ .

21. Subsoil movement of water.

N. K. BOSE, Lahore.

(i) Saturated flow.—

As was shown in my paper read last year before the Indian Science Congress, hydrodynamically the whole motion has been replaced by a fictitious fluid with different viscosity and density which have been called "Effective Viscosity" and "Density". With this assumption which can only be justified by comparing actual facts with the predicted ones, it has also been assumed that the motion in this fluid is extremely slow. Basing all the calculations on these two assumptions a relation between the velocity and hydraulic-head-gradient is found which is very much similar to the expression found by Darcy experimentally.

(a) Case of subsoil flow below a canal bed. Two cases are treated (i) when the subsoil is of infinite depth (ii) when there is, an impervious layer at a certain depth. In this case many interesting results have been deduced; and this is of very practical importance for waterlogging.

(b) Case of a subsoil flow over a weir. The unsteady case was dealt with last year.

(ii) Unsaturated flow.—

This deals with those cases when there is no saturated connection between the canal bed on the top and the subsoil water level. This is usually the case when the canal is just opened and also in the case when the subsoil water level is very deep. One rather interesting assumption has been made in dealing with this problem. In the case of unsaturated flow in porous soil, the pore spaces not completely filled up by fluid, whereas the connecting capillaries might be saturated. This means that from the capillaries to the pore space there is a sort of expansion and from the pore space to the capillaries a sort of contraction. This can be hydrodynamically represented by a volume network of sinks and sources with such a distribution of strength so that the total gain or loss is nil. On this a theory has been worked out and a case with the boundary condition of a canal bed on an infinite subsoil considered.

(iii) Flow of a flood down a river.—

Cases of a single wave either of elevations or depression have been dealt by Riemann, Airy, Rayleigh and others. In the present case the problem has been tackled three dimensionally and the motion of the disturbance down the river has been traced, taking into consideration that the river can expand laterally and overflow its banks.

22. Velocity of ultrasonic waves in gases and vapours.

S. K. KULKARNI JATKAR and H. E. WATSON, Bangalore.

Using a piezoelectric quartz crystal of 95,000 cycles frequency the wavelength and wave form in hydrogen, air, carbon dioxide, dimethyl ether and water, methyl alcohol, and ethyl ether vapours have been determined by a photographic method. The resonance curves are more complicated than those described by G. W. Pierce.

23. The measurement of the surface tension of a liquid from observation of the pressure necessary to neutralise its capillary rise.

G. SUBRAHMANYAM, Rajamundry.

The difference in pressure required to keep the meniscus within a capillary in the same horizontal plane as the free surface in the outer vessel is determined with the help of a manometer. The surface tension of different liquids and of the same liquid at different temperatures calculated by a direct determination of this pressure are remarkably consistent. The values for water, ethyl alcohol, benzene, and xylene at the room temperature and for water at different temperatures have been determined with three capillary tubes of radii 0.0825, 0.0401, and 0.02635 cms. respectively. Such an arrangement is found to be exceedingly sensitive and the results are independent of an accurate knowledge of the densities of the liquids concerned.

24. On the vibration of the shorter portion of the pianoforte string.

D. BANERJI and R. GANGULI.

The exact nature of the pulses generated by the impact of a hard hammer on a pianoforte string has not been experimentally studied so long, although they have got a very important bearing on the fluctuations of pressure between the hammer and the string as brought out by theoretical considerations. These pulses have been photographed and their theoretical significance has been discussed in the paper.

25. Further study of elastic behavior of India rubber.

G. B. DEODHAR and D. S. KOTHARI.

Variation of modulus of rigidity of India rubber with stress is experimentally studied. It is found that the rigidity increases linearly with stress up to the breaking point. Three samples are tried and the nature of vibration is the same in each case.

Qualitative study of effect of heat treatment on the modulus is made as a preliminary to precise methods of determination.

Values of Young's modulus for the samples are determined experimentally and the rigidity values are calculated from the equation $\eta = \frac{E}{2(1+\sigma)}$. It is found that the ratio of observed to calculated values of η is 2.2. Comparing this with the corresponding values for other materials it is inferred that India rubber behaves similarly with many other substances, the difference being only in magnitude.

26. Electricity of dust clouds:—Part I.

G. B. DEODHAR.

Observation on electrification of various dusts have been made by using a large volume of air at a pretty high speed. The climatic conditions are totally different from those under which other similar observations were made.

The number of substances tried is considerably increased. In some cases the sign of electrification is the same as that observed by Rudge.

The factors governing the phenomena of electricity of dust storms are stated as follows:—

- (1) Material of the dust. (2) Its size. (3) The gas raising the cloud.

(4) The velocity of the gas. (5) The temperature. Account of the first two factors is given in the present communication.

It appears that the electricity developed is of frictional nature, which itself is, of course, unknown.

Some quantitative estimates of electrification of chlorides of sodium and potassium are equally efficacious, whilst sodium nitrate is about $4\frac{1}{2}$ times as efficacious as potassium nitrate.

Dusts of various roughly uniform sizes were obtained with the help of a few graded sieves. The magnitude of the various sizes were obtained after very laborious observations under microscope. It is shown graphically that, other things being the same, the number of volts developed by blowing increases very rapidly as the size grows less.

27. Acoustic analysis of some auditoria in Madras.

H. PARAMESWARAN and S. KALYANARAMAN, Madras.

The paper deals with the acoustic analysis of some auditoria in Madras by applying Sabine's reverberation formulae. The principal defects of the halls are pointed out and suitable remedial measures are suggested.

28. Regularization of the problem of three bodies.

D. FERROLI, Mangalore.

The problem is stated; then Sundman's results are mentioned, which lead to regularization, but are outside the orbit of the equations of general dynamics.

Levi-Civita's method is subsequently explained, first with regard to the three bodies moving in one plane, where the regularization is obtained by a point-transformation, which leaves the equations of the system in their canonical form. Then the methods of dealing with the problem in space are mentioned. A point-transformation having failed the contact-transformation, suggested by Jacobi's method of integration, was tried with no better results.

The regularization of a binary collision in space was eventually obtained, by the introduction of two new vectors, by a contact-transformation, and by taking the canonical transformation from parabolic motion. Further, the complete regularization was got by means of a new parameter, which is symmetrical with respect to the three bodies. Finally, the facts that the regularization is purely quantitative, and that the equations are valid even after a collision, are mentioned, thereby enabling us to decide how far it is correct to say that the problem of the three bodies has been solved.

29. On sets of points which are permuted cyclically by linear substitutions.

A. S. KRISHNASWAMY IYENGAR, Mysore.

It is the purport of this paper to investigate the existence of certain linear substitutions of a finite order, which permute cyclically the vertices of an associated set of polygons. These polygons have many interesting properties, among which may be mentioned the following :—

1. The polygons have a circumscribed ellipse whose centre is their centroid.

2. The sum of the cotangents of the interior angles is constant.

3. The polygons can be projected orthogonally into regular polygons.

This investigation further shows that any linear substitution can transform definite species of polygons of the above type into similar

figures. In particular, if any polygon can be projected orthogonally into a similar polygon, it can also be projected orthogonally into a regular polygon and vice-versa. As obvious illustrations, it may be noticed that any triangle can be projected orthogonally into a similar triangle and any parallelogram into a similar parallelogram.

30. Evaluation of special persymmetrics. Part V.

M. BHIMASENA RAO and M. VENKATARAMA IYER.

(Parts 1 and 2 of this paper were read before the 5th Conference of the *Ind. Math. Soc.* and parts 3 and 4 before the 14th and 15th Annual Meetings of the Indian Science Congress.)

In this part persymmetric determinants indicated by

$$[2n+1A_{2n-s} \ 2n+1A_{2n-s+m-1}] \& [2n+2A_{2n-s} \ 2n+2A_{2n-s+m-2}]$$

are evaluated for integral values of $s \leq (n-1)$ in the first and $s \leq n$ in the second, introducing the convention that $2n+1A_{2n-s}=0$ for $s=1, 2, \dots, n-1$ and $2n+2A_{2n-s}=0$ for $s=0, 1, 2, \dots, (n-1)$. A few interesting numerical verifications of the results are also added at the end of the paper.

31. A theorem on probability applicable to Gaussian transformations.

M. VAIDYNATHAN, Madras.

The author discusses a theorem which gives the probability of a function $Q(x)$ characterised by general properties to lie within a contour $y \leq u$. Such a probability takes the form :

$$P(u) = \frac{1}{2} + \frac{1}{\pi} \int_0^{\infty} \frac{dt}{t} \int z \sin(u-y) t dx.$$

A detailed proof is given for the existence of the integral with the help of Dirichlet's discontinuity factor. The theorem is extended to the joint probability of n independent events and applied to simple transformations like $x = v^3$ when v follows the Gaussian law.

32. A class of solutions of Einstein's gravitational equations in material media.

J. GHOSH, Dacca.

The gravitational equations of Einstein for radially symmetric fields have been solved only in a few cases by Einstein, Schwarzschild and De Sitter. Two other special cases have also been worked out by the present writer. The present paper contains an investigation of a class of solutions which are more general than those hitherto obtained and include the above solutions as particular cases.

33. On the steady rotational motion of a liquid within fixed boundaries.

H. N. DATTA, Aligarh.

In a paper on the above subject published in the *Bulletin of the Calcutta Mathematical Society*, Vol. XIX (1923), Prof. B. M. Sen has investigated the relation between the form of the boundary with the possible distribution of vorticity. Assuming that the surfaces $\lambda = \text{const.}$ and $\mu = \text{const.}$ on which the vortex-lines lie are orthogonal, he has shown

(see Art. 3 of his paper) that in the general case of steady two-dimensional motion, the solution depends on the integration of

$$(t-r)(q^2-p^2)+4pqs=0.$$

Then, he has discussed this equation with results which can be summarised as follows :—

The equation belongs to Monge's type of differential equations with two intermediary integrals (each involving an arbitrary function); but Monge's method is of no use in this case since it does not give the most general solution (see Art. 4 of his paper).

In this paper, the author has (i) shown that the above conclusions of Prof. Sen are *incorrect*, (ii) obtained the most general solution of the above equation by what may be termed a combination of methods, and (iii) pointed out some special cases in which the hydrodynamical problem to which the equation refers can be easily discussed.

34. On the free vibrations of a gas enclosed in a rigid cylinder of elliptic section.

HRISHIKESH SIRCAR, Dacca.

(1) Considering a complete elliptic section, with a brief review of Mathieu's equation and its solutions, periodic and non-periodic, as developed by Prof. Whittaker and E. L. Ince, an attempt to calculate the frequencies corresponding to Mathieu-functions has been made.

(2) A similar attempt with elliptic cylinder functions of the second kind has been made, when the gas is enclosed in two confocal elliptic cylinders, including a special case when there is a rigid plane wall extending from one focus to the other.

(3) The analogous problem of the transverse vibrations of a membrane bounded by two confocal ellipses including a special case similar to what is mentioned in (ii) has been considered and the corresponding frequencies are determined.

35. A few cases of motion of a particle under central forces.

K. KASTAGIR, Chittagong.

In this paper, a few cases of motion of a particle under central forces in a resisting medium have been discussed and angular momenta for different laws of resistance have been worked out.

36. A novel solution of the nine-point circles of the 4 triangles whose vertices pass through 4 given points have got a common point of intersection.

L. SRIVASTAVA, Ajmer

37. Did the Babylonians and the Mayas of Central America possess place-value arithmetical notations?

S. K. GANGULI, Cuttack.

In this paper the writer disputes the opinion, held by some historians of mathematics in the West, that the Babylonians and the Mayas of Central America had possessed place-value arithmetical notations before the modern place-value notation was invented by the Hindus, the Babylonians having had a sexagesimal system and the Mayas a vigesimal one in supersession, in both cases, of previously existing non-place-value decimal systems. The grounds urged by the writer are :—

(1) Want of any other instance of supersession of the decimal scale of notation by a different scale in the available history of ancient nations.

(2) Practical difficulties of a tremendous nature consequent on the alleged supersession.

(3) Want of satisfactory explanation why the Babylonians should change the natural decimal scale for the unnatural sexagesimal scale and why the Mayas should introduce a unit which is 18 times, and not 20 times, as great as the next lower unit; and greater resemblance of the Maya system to a system of measures of time than to a system of notation.

(4) Use of sexagesimal or vigesimal units is no proof of the existence of a sexagesimal or vigesimal system of notation as shown by the use of the number 12 among the Scandinavian nations.

38. Reform of the Indian calendars.

G. V. KRISHNASWAMI, Chidambaram.

The calculations of the Indian calendars have been discussed by various writers from the chronological point of view. In this paper I deal with the main features of the Indian calendars and examine their agreement with observed facts.

The Hindu theory of the precession of the equinoxes and the terms *Sāyana* and *Nirayana* are explained. The meanings of the terms, year, *ayana*, month, *tithi*, and *naksatra* are considered and it is shown how two kinds of years, months, etc. (tropical, sidereal) are possible but that there can be only one interpretation for *ayana*.

The method of placing the *ayan*as and the months on a sidereal basis in the Indian calendars is defective and hence there is a difference of about 23 days in the calculation which difference will increase in course of time. The equinoxes and solstices will therefore occur at varying parts of the year and there will be a corresponding acceleration of the seasonal changes. The important function of the calendars is the regulation of the religious and sacrificial rites in accordance with the *shastras* and this function fails if the sidereal calendar is followed.

I make a few suggestions to bring the Indian calendars into line with actual observation.

39. An electric power-drive for large tower clocks.

H. PARAMESWARAN, Madras.

The mechanical force required to drive large tower clocks is considerable, and the energy from a falling weight is often inadequate when strong wind opposes the motion of the hands. To deal with such cases, an electric motor drive with controlled mercury contacts in vacuo is described.

40. Simple types of astro-camera.

H. PARAMESWARAN and H. SUBRAMONEY.

The paper describes some simple types of astro-camera locally made for the routine astro-photographic recording work, by inexperienced hands without elaborate and costly equatorial telescope mountings.

41. Meteorological normals of Calcutta.

V. V. SOHONI, Calcutta.

A historical reference to the origin of the Alipore Observatory is followed by a general description of the march of the seasons in Calcutta, quoted from Blandford. Then come notes explaining tables of normals. There are some 30 tables giving normals calculated from 20 years' records of autographic instruments and other observations. The elements dealt with are air pressure, surface air temperature, ground temperature, grass

radiation temperature, humidity, rainfall, cloudiness, surface wind velocity and direction, and upper air currents.

42. An interesting example of downward currents in the atmosphere connected with a N. Indian depression.

K. R. RAMANATHAN.

Following a shallow depression, a moderately strong dust storm passed over Agra on the evening of 30th March 1928. A series of eight pilot balloon ascents with balloons of the same size and free lift were made between 12 h 49 m and 13 h 21 m on that day.

These showed an interesting downward current at a height of about 1.5 km. The movements of these balloons and the changes of wind at the surface are discussed in relation to the structure of western depressions which pass over North India during the winter and hot season.

43. Microseisms associated with storms and the south-west monsoon.

S. K. BANERJI, Bombay.

The ground is never at rest and a seismograph provided with an aperiodic pendulum and a large magnification will always record these ever-present movements. Such a seismograph was installed in 1923 in the underground constant temperature room of the Colaba Observatory and its magnification was so arranged that it should record no microseisms when conditions were quiet over the neighbouring seas. It was then noticed that microseisms would make their appearance in the seismograms whenever weather was disturbed over the sea. Three distinct types of microseisms were recognized and these were associated with (1) the south-west monsoon, (2) the storms in the Arabian Sea and Bay of Bengal, and (3) local disturbance, such as pronounced land and sea breezes. Those associated with the south-west monsoon are steady vibrations, having periods varying from 4 to 10 seconds according to the strength of the air current over the sea. They are shown in the paper to be due to a type of standing vibrations on the Earth's surface combining to form progressive waves, analogous to Rayleigh waves, produced and maintained by the sea-waves generated by the monsoon currents. The microseisms associated with storms have periods varying from 4 to 6 seconds and show typical irregular variations in amplitudes, suggesting superpositions of waves of different periods due to existence of a marked difference in wind velocity in the storm and the surrounding areas. They make their appearance in the seismogram as soon as a storm has formed and disappear only after it has passed inland and ceased to affect the sea. The types are readily distinguished and thus throw open to the meteorologists a new method of forecasting the existence of storms. The microseisms associated with a local disturbance have large periods varying from 20 to 30 seconds, and are caused by waves over the shallow sea near the coast.

44. On some earth-current observations in the Colaba and Alibag Observatories.

S. K. BANERJI, Bombay.

The observations of earth currents have hitherto been made with lines many miles in length. Recently I made some experiments in the Colaba and Alibag Observatories with short lines, 250 yards in length. It is essential when working with such short lines to avoid the polarisation current altogether and this was attained by designing each electrode to be a combination of electropositive and electronegative metals in

suitable proportion so that the combined metal was neutral with respect to the soil. The actual composition of each electrode was determined by many trials. The neutral character is maintained if the electrodes are removed and scraped once a fortnight. Continuous records were obtained both at Colaba and Alibag by means of photographically recording galvanometers. The records at both these places showed the leakage currents from the electric railways at Bombay in a very conspicuous manner and these again showed remarkable agreement with the voltage record at the power station. The amplitude of oscillations of the leakage current is on the average 108 micro-amperes at Colaba and this is reduced to 5 micro-amperes at Alibag, situated 20 miles south-south-east of Colaba, agreeing roughly to the assumption of a laminar flow. It is calculated that the leakage currents at Alibag produce a magnetic field strong enough to affect the magnetographs and that the minute oscillations, which are noticed in the vertical force magnetograms, are due to this cause. The typical diurnal variations of earth-current, and features associated with 'magnetic storms' are shown in the earth-current records obtained at Alibag, but the leakage currents are the greatest disturbing factors.

45. Vortices on the monsoon front.

S. K. BANERJI, Bombay.

The south-west monsoon advances in most years from the south-east Arabian Sea first towards Malabar and then gradually north-wards along the west coast of the Peninsula with a clear discontinuous boundary, the monsoon air being relatively cool, moist and highly unstable and the air on the other side hot, dry and less unstable. Many little whirls form on this boundary and pass undetected except those which leave their traces on the Colaba autographic records. Even at Colaba, they were not recognized until two very typical vortices passed through Bombay on the 17th June, 1927, and forced attention to their existence. A search was made of the past records and several others were discovered to have passed through Bombay in previous years. These vortices have diameters of 20 to 30 miles. The central barometric depression in some of these could be easily explained by working out a theoretical vortex having the observed distribution of velocity. The monsoon fronts undoubtedly represent typical discontinuities in the tropics, analogous, though not quite similar, to the polar fronts in the extra-tropical region, the theory of which has been so elaborately developed by the Norwegian meteorologists (V. Bjerknes, *Geofysiske Publikationer*, Vol. II, No. 4). The succession of vortices, some well defined and others not so well-defined, which form on the monsoon front, is therefore of peculiar interest, for, when the detailed synoptical investigations are available they will eventually be found to be waves as well as vortices like those on the polar fronts.

46. Magnetic anisotropy of organic crystals.

K. S. KRISHNAN, Calcutta.

The well-known phenomenon of birefringence exhibited by liquids in a strong magnetic field points definitely to the magnetically anisotropic nature of the molecules, and in fact by correlating the birefringence with the known optical properties of the molecules it is possible to evaluate the anisotropy numerically. Its physical reality is, however, brought out more forcibly by measurements on magneto crystallic action. Where all the molecules in the crystal happen to be oriented in the same way, the anisotropy of the crystal as a whole is naturally a measure of that of the individual molecules. Conversely when the anisotropy of the molecules is already known from observations on magnetic birefringence in the liquid

state, the measurement of the susceptibility of the crystal in different directions offers a ready method of determining, in certain simple cases, the actual orientation of the molecules in the crystal. Taking for example naphthalene, the above method leads to precisely the same conclusions regarding the orientation of the molecules in the crystal, as the X-ray investigation of Bragg.

47. Kerr effect in viscous polar liquids due to radio frequency oscillating fields.

S. C. SARKAR.

The Kerr effect in highly viscous liquids consisting of polar molecules *e.g.*, octyl and higher alcohols has been studied, radio-frequency oscillating fields being used. As expected from orientation hypothesis the Kerr effect in undecyl alcohol, which is quite appreciable for small frequencies, almost disappears when the frequency is increased to about 2.6×10^8 . On the other hand the lower alcohols which are less viscous, continue to exhibit the effect even for such a high frequency. This may be taken as an experimental demonstration of the existence of a relaxation time.

For a wide range of frequency in the neighbourhood of the value corresponding to the relaxation time, the liquid exhibits a phenomenon quite different from the Kerr effect. Its origin is discussed.

48. The behaviour of phototropic mercury compounds in a voltaic cell.

Bh. S. V. RAGHAVA RAO.

The electrode potentials of the substances HS. Hg. CNS., I. Hg. CNS. and Hg_2S_2 (CNS)₂ have been measured in a voltaic combination in which (i) one electrode consists of the blackened phototrope and the other of the unchanged modification, both electrodes being in the dark and (ii) both electrodes are coated with the black phototrope and one is illuminated. It has been found that the photo-E.M.F. with any substance varies directly as the intensity of the light. By using a series of light filters it has been found that light of more than a certain wave length produces very little E.M.F. Dyeing in erythrosin extends the active region into the longer wave-lengths.

The temperature coefficient between 40 and 60° of the potentials of these combinations is very nearly 1.

49. Thermo-dynamics of the Compton effect with reference to the interior of the star.

S. CHANDRASEKHAR, Madras.

Considering collisions of the first and second kind between electrons and quanta in thermo-dynamic equilibrium, it can be shown that the product of the electrons and quanta in the first collision equals nearly the product of the electrons and quanta in the second collision (*i.e.*) the probability coefficients connected with the two processes are nearly equal.

In a system containing atoms, ionised atoms, electrons and quanta, two processes can happen—Compton scattering and reversed Compton-scattering (*i.e.*) recapture of an electron by an ionised atom by triple collision. In this case the product of the number of ionised atoms electrons and quanta (which represents the reverse process) has to be multiplied by a factor of the order of 10^{-27} to make it equal to the product of the number of atoms and quanta (which represents the direct process). On this basis the softening of the high frequency radiation created inside a star is explained as due to Compton-scattering with bound electrons. The contribution to the softening by Compton-scattering with

free electrons should be negligible since both the processes the direct and the reverse are probable.

50. The scattering of light by colloidal solutions.

A. S. MENON.

Part II. Iron, chromium and aluminium hydroxides. The state of polarisation and intensity of the light scattered by colloidal solutions of iron, chromium and aluminium hydroxides have been investigated. The scattered light is imperfectly polarised in a direction at right angles to the incident beam, but in all cases the maximum of polarisation is in that direction. The variation in the amount of depolarisation with the direction of observation has been determined. The particles in these solutions are anisotropic. The observed intensity of the scattered light agrees well with the values calculated according to the Einstein-Smoluchowski equation.

Part III. α - and β -stannic acids. Two samples of stannic acid solutions have been prepared, one from a dilute solution of stannic chloride (Zsigmondy's method) (α -stannic acid), the other from the product obtained by the action of nitric acid on tin (β -acid). These two acids differ in their chemical properties. The intensity of light scattered has been measured in each case for different angles and in the case of the α -stannic acid for different spectral regions as well.

Raleigh's fourth power law is obeyed in the case of the α -acid. The intensity of the light scattered by the acid in any direction is in agreement with the Einstein-Smoluchowski equation. The hypothesis that the α -acid passes into the β variety is not supported. An explanation is advanced for the different chemical properties of the two acids.

Part IV. Thorium and zirconium hydroxides. The scattering of light by colloidal thorium and zirconium hydroxides has been studied. The intensity and polarisation has been measured for different angles and for different spectral regions. The wave length has no influence on the amount of depolarisation, but the intensity of the scattered light varies inversely as the fourth power of λ . In all cases investigated the maximum polarisation is in a direction at right angles to the incident beam. It has been found that thorium hydroxide has a symmetrical structure but that zirconium hydroxide particles are anisotropic.

51. Theory of photo-elasticity.

KEDARESWAR BANERJEE.

Bragg and Hylleras explained the double refractions of some crystals by considering the mutual influence of the Lorentz doublets. The effects of these polarisation field in the case of a strained amorphous solid give zero birefringence, which is contrary to experience. Computation of birefringence in strained crystals according to Bragg's method, is complicated except for cubic crystals. Experimental data for the stress-optic coefficients for different directions of stress are available for rocksalt, sylvine and fluorite (rocksalt was tested also by the author). The values obtained theoretically do not conform to experimental results. The above facts are explained as due to the anisotropic deformations of the ions in the crystal due to their changed positions in the strained condition. The non-Lorentz portion of the density variation of refractive index arises from similar deformations and hence the birefringence is calculated from the known temperature variations of the refractive indices in those substances. This together with the Bragg birefringence, yields fair agreement with experimental results. According to this theory all the known facts regarding photo-elasticity in amorphous solids (viz., variation with temperature and composition of the material and the effect for strain beyond the elastic limits) are explained.

52. Absorption of light by the mixtures of chromates and dichromates.

G. R. PARANJPE and N. R. TAWADE, Bombay.

A. Hantzsch has investigated the absorption of light by the solutions of chromates and dichromate in the ultra-violet part of the spectrum. (*Zeitschr. f. physic. Chemie.* 72, 362, 1910). In the present work, the method has been extended to the solutions of the mixtures of these salts with a view to establish a method of estimating the proportions of the constituents in the mixture. In the visible and in the ultra violet part of the spectrum, the wave length where absorption just begins in the case of mixtures of definite composition lie at definite places between those of pure chromate and dichromate depending on the proportion of the constituents in the mixture. Results obtained so far go to show that for a given concentration of the mixture, the percentage composition is a function either of the wave length of the absorption edge or of the thickness of the solution which just causes absorption in a particular wave length. Thus the results can be applied to the determination of the proportion of these two ingredients in a mixture of unknown composition.

53. A method measuring the ratio and phase angle of a current transformer.

G. YOGANANDAM.

A new method of measuring the ratio and phase angle of current transformers is described. Formulae for the ratio and phase-angle are derived in terms of resistances and a mutual inductance M . Expressions for sensitivity for changes of the ratio and phase-angle are obtained. The results of a test on a current transformer are given. The advantages of the present method over the existing ones are pointed out.

54. Wave form of corona currents.

S. K. GOPINATH.

A valve circuit for amplifying small currents to enable their wave-shape to be recorded by the laboratory Oscillograph is described. The wave form of corona currents from a wire in a concentric cylinder and from a wire in front of a plane are obtained, and a typical wave analysed into its harmonics. A study of the critical corona voltages and of the rectification properties of corona is made with the help of Whitehead's arrangement.

55. The super-position of circular motions and its use in the exact determination of high frequencies.

T. S. RANGACHARI.

Equations are derived for the looped patterns resulting from the simultaneous super-position of two circular motions on a particle for the two cases when they are in the same or in opposite directions.

The shapes of the patterns are determined when the ratio of the two frequencies superposed are either integral or fractional. The use of this method in conjunction with a Cathode-Ray Oscillograph for the accurate determination of radio-frequencies is explained.

An expression is derived for the varying velocity assumed by the particle along the pattern and the special advantages resulting therefrom are pointed out.

A simple relation is found to exist between the ratio of amplitudes and that of the frequencies when the loops are just reduced to spots.

Cathode-Ray Oscillograms are reproduced in illustration of the theoretical results.

56. Behaviour of dry cells in a tropical climate.

C. VARADAN.

It is well known that dry cells deteriorate much more rapidly in India than they do in colder countries. An attempt has been made to find the reason for this and if possible, a remedy. The effect of storage under various conditions of temperature and humidity on the E.M.F., the internal resistance and the total discharge given by the cells has been studied. Chemical analyses of the cells before and after discharge have also been carried out. It has been found that mere soaking in water often restores the activity of a cell. The results obtained tend to show that deterioration of the cells is due to the drying up of the electrolyte and the formation of insoluble double chlorides and ammoniates.

57. Thermal effects in the polishing and figuring of optical surfaces.

H. PARAMESWARAN, Madras.

The paper deals with the local rise of temperature of the surface under polish which distorts the surface, a distortion which tends to accentuate the error in the surface. Methods of handling the surface under polish and the relative merits of fused silica, stainless steel, and glass are discussed.

58. Thermionic emission and catalytic activity.

B. S. SRIKANTAN.

The interaction of carbon dioxide and hydrogen at surfaces of platinum, platinum coated with barium oxide, and thoriated tungsten has been studied at various temperatures and the thermionic emission determined under similar conditions. From the results obtained it is concluded that thermionic emission appears to be a factor of decided importance in the activation of gases by catalytic surfaces.

59. On the effect of magnetic field on the dielectric constant of carbondioxide.

SNEHAMOY DATTA and SUBHENDU SEKHAR BOSE, Calcutta.

There has been a great deal of speculation as to whether a magnetic field should influence the dielectric constant. As early as 1920 and 1921, Hettner and Pauli Jr. solved the problem of motion of diatomic dipole molecules in an electric field on the lines of quantum theory and they concluded that if the magnetic field is at right angles to the electric field such gases should show negative polarisation and a dielectric constant smaller than unity. A new solution of the problem has been arrived at independently by Mensing and Pauli Jr. and Ven Vleck on the basis of the new wave mechanics and they claim that a magnetic field should have no influence on the dielectric constant. Some experiments have also been done with helium, oxygen, air, hydrochloric acid and even nitric oxide, confirming the above prediction.

In view, however, of the fact that Glaser has detected some anomalies of a controversial nature in the variation of susceptibility of carbon dioxide with pressure-anomalies which he failed to detect in other gases—a curiosity was felt to find the effect of magnetic field on the dielectric constant of carbon-dioxide gas.

Using a very sensitive heterodyne method as proposed by Gunn for

measuring changes of capacity by which a change of capacity of 10^{-15} farad could easily be detected, it was found that a magnetic field does produce a certain small change in the dielectric constant of carbon dioxide and there are certain anomalous features in the variation of the dielectric constant which somewhat resemble those observed by Glaser.

60. The influence of frequency on the dielectric constants of liquids.

M. A. GOVINDA RAU and R. W. LUNT.

With the aid of an alternating current bridge, the dielectric constants of benzene, chloroform, acetone, aniline, ethyl ether, nitrobenzene, and ethyl alcohol have been measured at 25° , as a function of frequency over the range 10^3 to 10^6 cycles per second. By using a modified form of Turner's liquid resistance, the effective parallel resistance of condensers filled with the above liquids was measured over the same frequency range. While the dielectric constants of benzene, chloroform, and ether remain practically constant, those of nitrobenzene, alcohol, acetone and aniline, increase with frequency. The parallel resistance also varies in the latter cases, showing a general increase, except for alcohol where it decreases. The changes at these frequencies must be due to the occurrence of molecular association.

61. The electric moments of ethylene chloride and ethylenedichloride.

P. N. GHOSH, Calcutta.

The paper deals with the determination of the permanent dipole moments of ethylene chloride and ethylenedichloride by a heterodyne null method. The well-known equation of Debye,

$$\frac{\epsilon - 1}{\epsilon + 2} \cdot \frac{M}{\rho} T = a + bT$$

has been applied to determine the values of the moments and are found to be 1.567×10^{-18} E.S.U. for ethylene chloride and 2.045×10^{-18} E.S.U. for ethylenedichloride. The electric moments of CH_3I , $\text{C}_2\text{H}_5\text{Br}$, $\text{C}_2\text{H}_5\text{I}$, CH_2ClI and CH_2Br_2 as determined by the author and published in a previous paper and those for other organic vapours determined by other authors have been discussed and an approximate idea on the constitution of these organic vapours has been suggested.

62. Measurement of dielectric constant of liquid mixtures.

N. N. PAL, Dacca.

The dielectric constants of nitrobenzene in benzene at different concentrations have been measured by the heterodyne beat method. Both dielectric and density data have been obtained at 27°C . Partial molecular polarisation P_2 of the solute molecule has been calculated by means of Debye's equation, and has been observed to increase with the decrease of concentration C_2 . From the zero concentration intercept on the curve P_2 versus C_2 , the electric moment of nitro benzene molecule has been calculated and been found to be in good agreement with that obtained by others. The molecular polarisation P of nitrobenzene has been observed to be related to N , the number of molecules per unit volume, by the equation,

$$P = a^1 + a \epsilon^{-\beta N^{\frac{2}{3}}}$$

where a^1 , a and β are constants.

Work with different mixtures is in progress.

63. A note on the determination of Stefan's constant with Denning's apparatus.

H. L. TANDAN, RAM SARAN and B. B. L. SAKSENA,
Lucknow.

The experiment, as described in Flint and Workshop's Practical Physics, was found to give inconsistent values of the constant. A correction for radiation from the underside of the silver disc, empirically applied, made the values of the constant as determined for different temperatures identical in value. This value was, however, still very much smaller than the proper value of the constant, being only a quarter of it in magnitude. The mass of the silver disc with lamp black and solder, and connected to the wires of a thermo couple element form a system of which the thermal capacity is rather difficult to specify with accuracy. Attempt at elimination of this error, like elimination of the error due to radiation from the under surface above mentioned, lead to no success.

64. On an arbitrary element in dilatational and resistance thermometry.

SATYENDRA RAY, Lucknow.

The variation of volume with temperature follows in general a law of the form

$$V_t = V_0 (1 + at + bt^2 + ct^3 + \text{etc.}, \text{etc.})$$

where a , b , c , etc., are other than zero for every substance. The temperature there is, however, nothing more than the VOLUME of the "thermometric substance." For the last we assume the relation

$$V_t = V_0 (1 + at)$$

so that

$$dv = k dt \quad (I)$$

as against

$$dv = k v dt \quad (II)$$

that is assumed for every other substance. The omission of the factor V from the R.H.E. of (I) makes the relation extremely arbitrary and indeed makes the true coefficient of expansion near the so-called "absolute zero" equal to infinity! Assumption of a certain expansion near $0^\circ A$ representing the same "interval" of temperature as an equal expansion in the neighbourhood of $0^\circ C$, say, corresponds to is extremely arbitrary.

This arbitrariness comes out immediately we replace the "thermometric substance" by a solid, in place of an ideal gas or mercury. Each substance will give an "absolute zero" of its own. Against this, if we apply formula (II) which corresponds to a relation

$$V_t = V_0 e^{at}$$

we notice the "absolute zero" becomes IDENTICAL FOR ALL SUBSTANCE.

The whole argument applies, *mutatis mutandis*, for resistance thermometry.

65. Longitudinal and transverse wave velocities in a solid.

SATYENDRA RAY, Lucknow.

Both of these waves can be easily proved to have velocities which vary with amplitude. This affects the treatment in quantum theory of

the problem of variation of specific heat of solids with temperature while giving a simple classical dynamics explanation of it.

66. On the "back wave" in wave motion.

SATYENDRA RAY, Lucknow.

In an article on "the failure of Fourier's analysis" published in B.M.S. proceedings of 1924, the present writer has drawn attention to the fact that the differential equations for progressive as well as stationary waves are identical in form. The solutions, therefore, should also be identical. The suppression of the solution $y=f(x+vt)$ has little justification. In the summer of 1926, at Nainital the writer noticed that the velocity of the ripples produced by throwing stones into the lake was extremely slow in the rear of the ripples in comparison with the velocity of the front. This is assumed to be due to the "back wave" at every stage of the wave motion that we ought to get.

67. On multiple reflection of a wave between two parallel walls distance $n(\lambda/2)$ apart very nearly.

SATYENDRA RAY, Lucknow.

It is shown that such reflection will give rise to a multiplicity of closely spaced equidistant nodes on two sides of the position for exact adjustment. This will give a simple explanation of striations in Kundt's Tube, vacuum discharge tubes and fine structure with interferometer of certain types, etc.

68. On a supposed failure of Maxwell's theory of tubes of force.

SATYENDRA RAY, Lucknow.

Poincare has pointed out the failure of Maxwell's stresses and strains for a tube of force which is reproduced in Starling's Electricity and Magnetism. The analogy is however a very specific one, *viz.*, of a rectangular bar of a solid acted on by forces at right angles to the faces and the strains taking place parallel to the forces. A *reductio ad absurdum* is supposed to be obtained in the result that the value of the "electric displacement" is found infinite when there is no electric intensity. If we notice, however, that the "electric displacement" has the "dimensions" of a surface density, and drop the specific analogy chosen, it would be found that the model is quite workable. The infinite value of the electric surface density can be seen to be the result of the infinitely large value of the Avogadro's Number for an ether gas built up of infinitely small electric charges. The displacement is not parallel but perpendicular to the lines of force at the two plane ends perpendicular to the line of force. The displacement is of the nature of the number of particles originally uniformly distributed in space concentrating in layers perpendicular to the line of force, while the linear density parallel to the line of force decreases in consequence. If any analogy in elasticity is to be sought, we shall find it in a flat spiral that would coil up when elongated; the increase of surface density being attended with increase in distance apart of the coils.

69. On the atomicity of the electric potential of colloidal silver in the recent work of O. Trauner in Vienna.

SATYENDRA RAY, Lucknow.

From Trauner's observations it is shown that the values of e/a for the different particles exhibit a law of atomicity.

70. On the atomicity of $d\lambda$ in the hyperfine structure of Cadmium line in the recent work of Dr. Anisiss Schrammen.

SATYENDRA RAY, Lucknow.

From new lines in the hyperfine structure necessity of the postulation of new sub-levels is claimed by Dr. Schrammen. The present writer shows an atomicity in the values of $d\lambda$ for the different lines as indicated in the theory submitted to the Lahore session of the Congress.

71. On X-ray and visible spectrum analogies.

SATYENDRA RAY, Lucknow.

In seeking analogies in X-ray and visible spectrum phenomena certain outstanding points seem neglected. There is no "practical" analogue, *e.g.*, of powdered crystal and rotating crystal methods in the visible region. As no spectroscopist working in the latter region, in the writer's knowledge, works with a prism of powdered glass or quartz, or rotates his prism periodically during exposure, or thinks of even extending, mathematically, the analysis to the visible or ultra violet regions, the present writer doubts if the interpretation of photographs in the X-ray region is entirely correct.

The fact of crystalline and amorphous solids, and even solids and liquids behaving in the same manner in X-ray phenomena should not be utilized to build up a theory of solid structure of liquids, when in the history of physics the luminiferous ether has been sent to the limbo of exploded theories for doing the same.

Again the scattering of luminous waves by solids and liquids investigated by Prof. Raman militates against the space lattice structure of Bragg and Laue. If the "atomic planes" be billowy for the long luminous wavelengths, it is difficult to conceive how these very atomic planes are stationary for the infinitely shorten X-ray wavelengths to be able to give the "reflections" in the various directions of Bragg's analysis.

It appears in the amorphous substance, the rotating crystal, powdered crystal and the liquid we have an X-ray analogy of a well known principle of physical optics according to which a random distribution of identical diffracting patterns gives us an intensified edition of the diffraction due to a single one of these. This is why crushing, rotating, or liquifaction makes little difference, or if any, a difference for the better. At any rate the X-ray diffraction phenomena admittedly look very much like halos of physical optics.

72. On the resonance excited by an impressed vibration with decaying amplitude.

N. N. BOSE, Lucknow.

It is shown that the resonance excited by such an impressed force in a particle subject to a damping resistance is of the nature of a continuous spectrum of all possible wavelengths with their amplitudes varying in the particular manner given by Lommel's analysis.

73. On the evaluation of the integral $\int_0^{\infty} e^{-x^n} dx$.

N. N. BOSE, Lucknow.

In the *Proceedings of the Benares Mathematical Society*, Vol. IV, the author has given a method of evaluating the above integral by a method

depending upon successive reduction. In the present note the same has been done by simpler methods.

74. On the evaluation of the integral

$$\int_0^{\pi/2} \frac{d\theta}{(a^n \sin^n \theta + b^n \cos^n \theta)^{2/n}}, n > 2.$$

N. N. BOSE, Lucknow.

The above integral has been evaluated by Dr. Glaisher in the *Proceedings of the London Math. Soc.*, Vol. 12. A simpler method by the present writer is given in the *Proc. Ben. Math. Soc.*, Vol. VI. A simpler method still is given in the present note.

75. On the damping factor of a ballistic galvanometer.

D. V. GOGATE, Baroda.

Ray found that correct values of capacity and Inductance was not found unless the damping factor for the ACTUAL CIRCUIT was determined experimentally or by extrapolation, and that the formula

$$\lambda = a \left(\frac{1}{R} + p \right)$$

was not correct. This has been carefully tested and the experimentally obtained mode of departure from the theoretical formula is given in graphs showing the mode of variation of a and p with R .

76. On anomalous values of Galvanometer resistance.

D. V. GOGATE, Baroda.

Experiments for the determination of Galvanometer resistance by the method of substitution gave values which were found atomic. These values were confirmed by means of a Wheatstone's Bridge with an alternating E.M.F. Ray has noticed previously atomic values of L and C with a Drysdale's Bridge, which he attributes to different "harmonics" of the E.M.F. obtaining in different arms of the bridge. The multiple values of RESISTANCE found with STEADY CURRENTS, however, do not admit of the explanation given for atomic values of CAPACITIES and INDUCTANCES.

77. Relativity in thermometry.

TRIBHUWAN PRASAD GAURGAS, Lucknow.

In dilatational thermometry in the (v, t) graph we really plot the volume of one substance against another, the second being called the "thermometric substance." If the role of the two substances be interchanged a simple geometrical relationship will subsist in the two (v, t) graphs obtained. By suitably defining "points of temperature" it is possible to obtain the SAME graph for the two cases, viz., a straight line through the origin. It is obvious this temperature scale would be less liable to arbitrariness than the ones obtained by assuming any single one of the given substances alone to expand "regularly."

78. On the compressibility of water vapour before and after condensation.

BABU RAM KAPILA, Lucknow.

At the suggestion of Satyendra Ray it was attempted to compare these compressibilities by assuming that the vapour was condensed into the form of N drops of equal diameter, the drops being merely the vapour, only being enclosed in a film of surface tension T . It is found from this view point that the vapour inside this bubble is more compressible than the vapour outside, and that the value of N increases with temperature.

79. On the Failure of Ohm's and Kirchhof's laws for an alternating E.M.F. in a circuit possessing capacity and resistance in series.

MAHMUDUL HASAN AHMADI, Lucknow.

The two above mentioned laws are based on the assumption of a steady E.M.F. producing a current which is the same at every cross section. In a circuit possessing resistance alone the phase of the E.M.F. must agree with the phase of the current, unless the resistance is a function of time. With capacity it is difficult to conceive why any difference in Phase between the E.M.F. and Q should exist. The last case is considered with the condition of identity of phase of either current or charge with the E.M.F. and it is shown that r and C will be variable with time.

80. X-Ray diffraction in terpenes and the application of the method to classification.

V. I. VAIDYANATHAN, Calcutta.

Employing $Cu K\alpha$ radiation, a systematic examination was made in 21 liquids, belonging to the terpene series. The investigation reveals the following facts:—(1) When attention is confined to one series of compounds, X-ray diffraction enables a general classification of the liquids though at present it cannot be considered as unique. (2) The olifinic long chain terpenes are found to possess a diameter of 4.95 \AA° , the mono and dicyclic terpenes of the formula $C_{10}H_{16}$ diameter of 5.5 \AA (average) and sesquiterpenes of the formula $C_{15}H_{24}$ nearly 7 \AA° . (3) Within small limits, the isomers of cyclic compounds differ in their diameter. Double X-Ray haloes occur in many liquids. A striking feature of the sesquiterpenes was that they gave 3 haloes. The relative positions of the side branches influence the nature of the X-Ray haloes. (4) Due to the side groups, the olifinic long chain terpenes have an increase in diameter of 0.4 \AA° , when compared with a normal chain.

Explanations are offered for the main features of typical and widely different haloes, in the light of Raman and Ramanathan theory, i.e. the X-Ray diffraction peaks in liquids occur at wave-lengths equal to the mean molecular distances between them.

81. X-ray diffraction in liquid mixtures.

P. KRISHNAMURTI.

Several binary liquid mixtures have been investigated using the $K\alpha$ radiation of copper.

Aqueous Systems:—Mixtures of various concentrations in which the other component was phenol, trimethyl carbinol, piperidine, pyridine, butyric acid, ethyl alcohol, glycerine and lactic acid respectively were

examined. In solutions of the first three liquids, the rings due to the two components exist separately in the pattern for the mixture, at approximately the same angle as in the pure liquids, but more diffuse. On the other hand, with glycerine, ethyl alcohol and lactic acid solutions, only one ring is observed at an angle intermediate between those of its components, depending on the concentration. The two effects are slightly modified in solutions of pyridine and of butyric acid.

Non-aqueous systems :—Mixtures of methyl salicylate and O-nitro benzaldehyde or of aniline and cyclo-hexane, give almost the same patterns as for the pure liquids. But in a mixture of methyl salicylate and cyclo-hexane, where the molecules are quite dissimilar, the pattern is also entirely different.

The presence of groups containing several molecules of each component separately is postulated in aqueous solutions of the first group by analogy with sodium oleate solutions previously considered.



82. X-ray diffraction in liquid alloys of sodium and potassium.

KEDARESWAR BANERJEE.

A series of X-ray diffraction haloes produced by liquid alloys of sodium and potassium of different compositions have been studied. The alloy is here regarded as consisting of the excess of sodium or potassium dissolved in the liquid compound Na_2K and the results are found to be in accordance with the results of Wycoff and Krishnamurti for X-ray diffraction in aqueous solutions. When the amount of the dissolved metal is small compared to the amount of the solute Na_2K , the halo is nearly the same as that given by Na_2K , and when the amount of either of the metals preponderates to a large extent, the diameter of the halo is nearly the same as that given by the metal. In the intermediate stages the effect may be regarded as a superposition of the effects due to Na_2K and the metal in excess. It is also concluded that the three atoms of this compound are placed at the angles of a triangle. A faint inner ring presumably due to Na_2K is observed in cases where the excess of either of the metals is very small.

83. An X-ray investigation of the crystals of azo-benzene.

MATA PRASAD.

Crystals of azo-benzene ($C_6H_5-N=N-C_6H_5$  $-N=N-$ )

have been studied by Becker and Jancke (*Zeitsch. physikal. chem.*, 1921, 99, 242) in the state of compressed powder by a combined method of Bragg and Debye and Scherrer and found that the dimensions of the unit cell are

$$a=12.50\text{\AA}^\circ, \quad b=5.28\text{\AA}^\circ, \quad c=8.38\text{\AA}^\circ \quad \text{and} \quad \beta=116^\circ$$

the crystals belong to the monoclinic prismatic class. The density of the crystals being 1.235, the unit cell, according to them, contains only two molecules.

The crystals of azo-benzene have been studied by the author by the rotating crystal method and the dimensions of the unit cell have been found to be

$$a=12.65\text{\AA}^\circ, \quad b=6.06\text{\AA}^\circ, \quad c=15.60\text{\AA}^\circ \quad \text{and} \quad \beta=114.24^\circ.$$

The c axis is twice that found by Becker and Jancke and the unit cell contains four asymmetric molecules. By taking the oscillation photographs about a and b axes it has been found from the halvings of the planes that the crystal belongs to Γ_n lattice and the space group C_{2h}^{15} . With twice c axis very strong reflections are obtained from planes corresponding to the natural faces of the crystals.

It has been further shown that the crystals may also belong to pseudo-orthogonal class and this view has been confirmed by the intensity of reflection from corresponding planes. The dimensions of the orthogonal cell and the molecule indicate that the molecules lie along 201—direction of the monoclinic cell, and the plane of the molecule is almost perpendicular to the *ac* plane. This orientation of the molecules explains the order of intensities of reflections from a number of important planes.

The diamond structure of the benzene ring gives a nice locking of molecules in the cell. The two benzene rings in the molecule are so attached to nitrogen atoms that one is almost a reflection of the other. This shows that the molecule is not entirely asymmetric but possesses a plane of pseudo symmetry.

84. On atomic refractivity.

S. C. BISWAS, Dacca.

By calculating in the ways of Lennard-Jones and Van Vleck the di-electric polarisation of the medium in terms of the energy change of the second order Stark effect in Epstein's equation, for normal hydrogenic atoms it can be shown that

$$(\mu-1) = \frac{Nh^6n^4(15n^2+21)}{64\pi^5e^6 \cdot m^2(z-s)^4} = \frac{Ne^2(15n^2+21)}{64\pi m\nu_0^2}.$$

when expressed in terms of the frequency for infinite wavelength; n represents the principal quantum number, $(Z-s)$ effective nuclear charge, s being the screening constant. Discussion of this expression in the light of Kramers theory of dispersion is considered. Effective nuclear charges, and atomic radii as understood in the sense of Mosotti have been calculated. According to Cuthberston effective number of dispersion electrons per unit volume is q times the number of atoms, q being a numerical constant differing with different atoms. An interpretation of this numerical quantity has been given in terms of the quantum number. On a comparison of this equation with Cuthberston's values of q and ν_0 (free or dispersion frequency) ν_s has been calculated. The energy equivalents of ν_s , ν_0 and ν_∞ (ionisation frequency) are given in volts;—

TABLE I.

	He	Ne	A	Kr	Xe
$h\nu_s$ (volts)	23.47	26.42	17.68	18.36	18.91
$h\nu_0$ (volts)	24.33	25.60	16.97	14.70	12.34
$h\nu_\infty$ (volts)	24.50	21.50	15.40	13.30	11.50

It is clear from the table that the three frequencies cannot be exactly identical, rather that $\nu_s > \nu_0 > \nu_\infty$. Considering atoms in the excited states values of ν_s may be somewhat reduced.

85. On Cuthberston's data of absorption experiments in the extreme ultra violet.

S. C. BISWAS, Dacca.

In an attempt to investigate the characteristic absorption bands in the extreme ultra violet corresponding to the free vibration period of electrons in rare gases, Cuthberston has recently obtained a set of very interesting results. It has been observed in the (previous abstract) that ν_0 (the dispersion frequency) is greater than ν_∞ (the ionisation frequency). On the theory of photo-electric effects in vapours ν_0 and ν_∞ may be connected by $h\nu_0 = h\nu_\infty + \frac{1}{2}m\nu^2$ which means that extending from the series

limit on the short wavelength side, there will be a region of continuous radiation. Cuthberston's results of absorption experiments show that for Kr and Xe, absorption begins either at ν_∞ or at a frequency just greater than ν_∞ . For Ne, A and He, however, absorption begins on the longer wavelength side of the series limit, within the region of resonance wavelengths which are capable of bringing about photo-ionisation by a secondary collision with an excited and normal atom. Cuthberston has noted the beginning of absorption band in He at (λ 858) which is apparently incapable of bringing about photo-excitation. It seems more probable however that in He, absorption begins at (λ 651 or 595) where Cuthberston has observed faint lines at a pressure of 0.01 mm. Absorption maxima have been noted in the cases of Kr and Xe only. These correspond to frequencies greater than ν_0 in any case.

86. On metal crystals.

S. C. BISWAS, Dacca.

A relationship was shown to subsist between ionisation potentials and compressibilities of atoms in the solid state, (*Proc. Indian Science Congress*, 1927). Strikingly enough elements of group (I. B.) differ from elements of group (I. A) or of group (II. A) to which they are cognate respectively in valency and in structure. This discrepancy can be explained on the assumption that the exponent of repulsive force 'n' in Born's equation of force combined of an attraction and a repulsion term should differ in two cases.

Metal crystals for elements of group (I) have been considered from the standpoint of Haber and J. J. Thomson. Both methods give identical repulsion exponents and grating energies [V_M]. V_M given by J. J. Thomson (The Electron in Chemistry, p. 121.) appear too high. From purely experimental data V_M has been calculated on the basis that by evaporation of metallic crystals isolated atoms could be produced which are capable of subsequent ionisation i.e., $V_M = J + D$ where J represents ionisation potential, and D sublimation. Another method of calculating V_M from the work of dissociation of crystal ions into free gaseous ions, i.e., $V_M = \phi_e + \phi_M$ where ϕ_e represents energy of expulsion of electrons from solid metals and ϕ_M that of positive ions, has been considered.

ϕ_e has been calculated either from (a) the thermionic work function in Richardson's equation for electron emission or from (b) the photo-electric threshold frequency.

ϕ_M has been calculated from the heat of hydration of gaseous ions. This method involves a series of thermo-chemical calculations. Values of ϕ_M as determined is less than J , which indicates that electron affinities in the cases of individual gas atoms and in the cases of assemblage of crystal ions should differ.

87. X-ray examination of the molecular structure of oxalic acid dihydrate.

A. N. SARKAR, Aligarh.

Anhydrous oxalic acid crystallises in the orthorhombic bipyramidal class whereas oxalic acid in the monoclinic prismatic class. The latter was taken for x-ray examination with a view to fix the position of the two water molecules. 'Powder photograph' of the crystal showed 15 diffraction lines. Comparison of spacings as calculated from data given by Groth with those observed on the photograph suggested two alternative solutions viz.,—(1) number per cell is 2, space-group C^{52}_2h (2) number per cell 2, space-group C^{32}_2h . In the latter case the strong line at spacing 2.26\AA should be attributed to second order of plane 101. A detailed

analysis of a Laue photograph of the crystal perpendicular to face a (001) showed that abnormal intensity of spots due to rather complex planes 032, 234, 311 is accountable only in case (1).

Results :—Number of dihydrate molecules 2, axis of 2-al rotation a screw axis, plane of symmetry a glide plane with translation ($\frac{1}{2}a + \frac{1}{2}c$). These considerations directly fix the second molecule at the centre of the unit cell. A molecular structure of the dihydrate molecule is suggested purely from consideration of volume and cleavage and a model presented.

88. J-absorption discontinuities in silver and tin.

S. R. KHASTGIR, Colombo.

Barkla and Khastgir have shown in the Phil. Mag. for Oct. 1927 that in the relative absorption of the primary and scattered X-radiations by aluminium, copper, silver, tin and gold, the ratio of the ionisations produced by the scattered and primary beams when they are *unintercepted* and *intercepted* by similar sheets of the absorbing material was amazingly regular and continuous over a long range of absorbabilities from

$$\left(\frac{\bar{\mu}}{\rho}\right)_{Al} = 4 \text{ to } \left(\frac{\bar{\mu}}{\rho}\right)_{Al} = 4.0.$$

In the present paper, it is proposed to furnish further experimental result obtained with silver and tin, which show the discontinuous nature of the absorption by scattered X-rays. The ratio $\frac{S}{P}$ of the ionisations produced by the scattered and primary radiations appears to be constant for various thicknesses of silver and tin. Thus several horizontal lines in steps are obtained. The steps appear at definite places and they are under control, inasmuch as they appear earlier or later in the curve, according as the ray is hard or soft. The following gives the values of mass absorption coefficients in aluminium for the various discontinuities in silver and tin.

Absorber	$\left(\frac{\bar{\mu}}{\rho}\right)_{Al}$
Silver	1.4, .9, .7
Tin	1.2

In tin, the following *alternative* results are obtained :

(1) A gradual fall in the ratio S/P, when plotted against the thickness of the absorbing material, or (2) the constancy of the ratio with a sudden transition to a lower but *constant* value. These evidently correspond to the *absorption edges and lines*. The continuous nature of the absorption as evidenced more frequently in our experiments as well as in the recent experiments of O. Gaertner (*Phys. Zeits*, 15th July, 1927) and R. T. Dunbar (*Phil. Mag.* May 1928) is only an alternative feature in the J-phenomenon. The results of Gaertner and Dunbar substantially agree with our results with aluminium.

Even allowing for the energy distribution among the different constituents of the more or less heterogeneous radiation, the results are at variance with Compton's theory of scattering.

The experiments were performed in the Physical Laboratory of the Edinburgh University.

89. The region of Barnard's dark objects in the Hyderabad Astrographic Zones.

T. P. BHASKARA SHASTRI.

Barnard has catalogued 349 dark objects from his large collection of celestial photographs. 65 of these objects occur in the regions of the

Hyderabad Astrographic Zones. The number of stars on a few plates of corresponding areas has been counted and it is found that, even in the large scale photographs of Hyderabad, these curious objects are fairly conspicuous. The detailed counts are presented on twelve of these regions.

90. The star density in the Hyderabad section of the "Carte du ciel."

T. P. BHASKARA SHASTRI.

The belt of the sky between Decl -17° and Decl -23° has been assigned to the Nizamiah Observatory, Hyderabad, for the "Carte du Ciel." It consists of 1,260 photographs which have been taken and completely measured. The star density per square degree varies considerably in different hours of Right Ascension, being greatest in regions near the galactic equator and least near the poles. The variation is tabulated and discussed.

91. On the fine structure of the spectrum lines of Zinc.

WALI MOHAMMAD and S. B. L. MATHUR, Lucknow.

By means of a Hilger Quartz E Spectrograph and a Quartz Lummer Gehrcke plate 13 cms. long and 0.46 cm. thick, the authors have investigated the fine structure of all the important lines of Zinc between the region λ 5000 A and λ 2756. The source of light was a specially constructed lamp consisting of a Wehnelt Oxy-Cathode of platinum and an anode of Zinc both placed in a water-cooled tube kept exhausted by means of a Cenco-Havac Pump. Most of the lines show a complex structure and the position of the satellites has been fixed both in the visible and the Ultra-Violet region.

Section of Chemistry.

President :—PROF. J. N. MUKHERJEE, D.Sc.

Presidential Address.

THE PHYSICAL AND CHEMICAL POINTS OF VIEW IN THE THEORETICAL TREATMENT OF COLLOIDS.

Rapid progress in the basic sciences of Physics, Chemistry and Biology has led, on the one hand, to specialisms, and on the other, to new orientations of border sciences out of which have emerged in the course of time departments of scientific study with novel characteristics of their own. Colloids form an example of such orientations and share a common characteristic of these developments, namely, that observations rush in so quickly that their theoretical treatment can scarcely keep pace with them. The manifold character of colloidal phenomena at times becomes the despair of those who attempt at a systematic presentation of the subject. But the great interest and novelty of the phenomena have induced increasing numbers of workers trained in the methods of physics and chemistry to take up this task. To-day a struggle for recognition as the basis of a systematic treatment, is going on between two rival schools of thought which have respectively a physical and a chemical bias. In the text books on colloids we get evidence of this bias together with an attempt to hold the balance equally between the claims of these two rivals.¹ In some groups of phenomena, or, particular colloidal systems, the one or the other school shows obvious advantages. There is, however, a wide field where both points of view are simultaneously advocated by rival champions. Obviously there will come in course of time a synthesis, in which this rival orientation to their theoretical treatment will be reconciled, and the science of colloids will acquire its distinctive setting, being freed from the apron-strings of the purely physical, or, the purely chemical standpoints. At present our ignorance of the real theoretical relationships leaves us the only possible alternative of interpreting the observations in terms of those physical and chemical considerations which have been found useful in understanding groups of phenomena in physics and chemistry bearing strong resemblances to them. We shall consider the respective merits of these two rival presentations in some typical instances. Such an analysis will also give us a glimpse of the special characteristics of colloidal phenomena.

A. THE COLLOIDAL PARTICLE AS A MOLECULE IN THE
PHYSICAL AND IN THE CHEMICAL SENSES.

A sol as a 'one phase' system—The Brownian Movement of the particles in a sol as demonstrated by Perrin, Svedberg and others leaves no doubt that they behave as a molecule in the sense of the kinetic theory of gases. In chemical thermodynamics however the word molecule has a different connotation and the question whether these particles can be treated as dissolved molecules has troubled colloid chemists for a long time. We meet with this question in the discussions² as to whether a colloidal solution is to be considered as a 'one phase' or as a 'poly phase' system. In chemical thermodynamics the concept of 'a component' is fundamental and the concept of a molecule is inseparably associated with that of a component in 'a homogeneous body' or a 'phase.'³ If colloidal solutions in general are to be considered as 'one phase' systems we should try to visualise the components of the phase. In a 'homogeneous' mass or a 'one phase' system at constant temperature and pressure the chemical potentials of the components are unequivocally determined by the chemical composition of the mass provided the structure does not vary. In fluid phases, such as *ordinary solutions*, the structure of the mass is not an independent variable (see later) and if colloidal solutions are to be treated likewise the chemical composition of the solution should, at constant temperature and pressure, unequivocally determine the chemical potential of the components. Can we say that of most colloidal solutions? The question must be answered in the negative. Thus the particles in a colloidal gold solution do not constitute a 'component'; for, a definite chemical composition of the mass cannot be expressed in terms of 'components' or 'chemical molecules'^{3a} which have an invariable average mass and at constant temperature and pressure the molar fractions of the different components will not be constant even when the mass has a definite chemical composition. We see that the mass is not a phase as defined by Gibbs and that such systems require special treatment. Once they are separated by evaporation or freezing the particles in the separated mass do not diffuse spontaneously into the liquid.

A gel as a 'one phase' system—This is, however, the case under certain conditions with a large number of colloids where the sol→gel transformation is reversible but shows certain special features. Sørensen⁴ considers that the 'solution' of egg-albumin is identical with 'solution' and attributes a definite solubility to it. This substance should thus be regarded as a single component (pure phase) but then, as we shall see later, it loses its special interest as a colloid. Unfortunately we cannot build too far on this basis, for the difficulties⁴ in preparing a sample with definite solubility show that small quanti-

(3)

Presidential Address.

ties of electrolytes associated with proteins profoundly change their properties, and that it is difficult to fix definitely the number of components. Besides, the characteristic colloidal properties such as ageing, or, hysteresis, indicate that we are not dealing with one unequivocally defined phase but at least with successive phases. This fact alone is not incompatible with the assumption that a gel is a 'one phase' system, for, we know that the chemical potential of a component, in a 'homogeneous mass' having a definite chemical composition and at constant temperature and pressure, also depends on such factors as the structure of a crystal or the size of a drop. On the other hand the different states of the gel, varying with age, or, responsible for hysteresis, may be due to changes in the character of the molecules composing it such that new components must be considered. Also the different molecular species may not be in thermodynamic equilibrium. Proteins easily suffer chemical decomposition such as hydrolysis. Thus the uncertainties as to the number of components and of the structure present difficulties in correctly defining the gel as a phase in the thermodynamic sense.

Additional variables foreign to usual thermodynamic treatment of chemical systems—So far we have not considered those properties of these gels which present difficulties against their being classed as 'one phase' systems. Many gels show electro-osmosis, a property associated with electrical separation at an interface. If a gel be treated as a 'one phase' system, then, since the conduction of electricity is entirely the result of a unidirectional flow of the liquid, the transport of liquid must be treated on the same basis as the transport of matter in crystals,⁵ where the conduction of electricity is by ions of one sign only. The transport of the liquid in such cases may also be treated in the same way as the transport of water in electrolysis which we meet with in the experiments of Washburn.⁶ There is, however, an essential difference. In the conduction of an electric current in an electrolyte, or, in a crystal, the 'mass density' of the charge of the different carriers of electricity, (in other words, the amount of matter, irrespective of its structure and nature, transported with a definite quantity of electricity) is not an independent variable. Gibbs⁷ has considered this point in detail as will be seen from the following quotation:

"We know by experience that in certain fluids (electrolytic conductors) there is a connection between the fluxes of the component substances and that of electricity. * * * Since the motion of the fluid as a whole will not involve any electrical current, the densities of the components specified by the suffixes are not independently variable like the densities of the components which we have employed in the other cases."

But in these cases *these densities are independently variable*

because the electro-osmotic flow depends on the size of the capillary pores, or, the state of dispersion and the quantity of matter transported is not wholly determined by the chemical composition and the quantity of electricity carried by it. Further many gels show what is known as a 'streaming potential.' Thus if an (small) amount of liquid be squeezed out of a (large) mass of a gel and made to flow through a (small) diaphragm of the gel, we get an electric current. We see that '*the motion of the fluid as a whole involves an electric current*' and an additional variable, namely, electrical density must be considered so far as the moving liquid is concerned.

These variables do not necessarily render the mass 'non-homogeneous' in the thermodynamic sense so long as the chemical composition unequivocally determines such factors as the degree of dispersion and the electrical density, for, then they cease to be 'independent' variables. This is probably the case with some substances of high molecular weight but in by far the larger number of instances it is not so. At any rate in those colloidal systems, where the main stress has to be laid on these additional variables which distinguish them and where the chemical composition does not unequivocally determine their values, it should be recognised that they require a distinct and more comprehensive treatment than is usual in chemical thermodynamics. For example, the electro-kinetic phenomena referred to above cannot be treated thermodynamically as being a property of the 'homogeneous mass.' It is characteristic of 'non-homogeneous regions' in the mass which, as a whole is electrically neutral.

We have treated this question at length to show that an extension of the principles underlying chemical thermodynamics to such systems (when in thermodynamic equilibrium and for the purpose of accounting for colloidal phenomena) must consist in recognising additional variables which are foreign to the usual treatment and some of which are characteristic of non-homogeneous regions.

The physical point of view essentially recognises the same variables but looks upon such a system as an agglomerate of particles and emphasises that a proper understanding of the properties of these systems *would lie in the peculiarities of interfaces*.⁸ It has the advantage of offering a basis for theoretical treatment of those properties where thermodynamic considerations are not useful as also in those systems where one cannot be sure that there is an actual thermodynamic equilibria, or, where the number of components and additional variables are not definitely known. Properties such as the electro-osmotic flow in a capillary tube which are characteristic of an interface, undoubtedly enable us to understand a large group of colloidal phenomena and has been of great help in explaining them.

B. THERMODYNAMIC TREATMENT OF COLLOIDAL SYSTEMS.

A proper thermodynamic treatment of colloidal systems should therefore incorporate in it their special characteristics. We shall attempt to give an outline of such a treatment. We see that a colloidal system such as a jelly or a sol may be considered from two alternative points of view :—

- (1) It is a 'homogeneous mass' consisting of components in thermodynamic equilibrium and that its special properties as contrasted with similar ordinary chemical systems arise out of peculiarities regarding the size or structure of the components.
- (2) It is a heterogeneous mass, a 'disperse system' (Wo. Ostwald) whose properties can best be understood from a consideration of the peculiarities of interfaces and in terms of degrees of dispersion, size of the particles and the structural relationships of the particles and their interfaces.

In their extreme forms, namely, ordinary molecular systems, or, coarse suspensions, or, physical mixtures there is no difficulty in deciding which of these views is more suited for their treatment. But we meet with all stages of gradation between these two extremes and *the problem before us is to outline the principles which will definitely characterise each point of view so as to prevent a confusion as to their implications.* It will be seen from the above that the fundamental factors are the same in each case. Thus the difference is essentially one of the concepts used. For example, we meet with a heterogeneous distribution of electrical densities in the immediate neighbourhood of ions in solution or in crystals but we do not call such regions of discontinuities 'interfaces.' As the size of the unit, the molecule or the charged particles (the ion), grows we may ultimately come to a stage where there is no doubt that we are dealing with what we should characterise as an interface. So we have to find out at what stage the non-homogeneous region becomes an 'interface.' We see that the problem consists in clearly defining these concepts namely, a 'component,' a 'homogeneous mass' or 'phase' as used in chemical thermodynamics, an 'interface,' 'structure' of phases and thermodynamic equilibrium.

Now I do not presume to say that these concepts are not known to all of you, nor do I presume to substitute new definitions of well known concepts in the place of those laid down by the classical teachers of chemical thermodynamics. It, however, appears from the literature that in borderland cases there has been some confusion. I have entertained an impression for a long time that most of the controversies usually met with in the literature have arisen from not correctly adhering to those

classical definitions and I am confirmed in this opinion by a recent article by Bancroft.⁷

I therefore propose to present before you an analysis of these fundamental concepts. It would perhaps be not out of place to mention that the 'phase' rule as deduced by Gibbs applies only to equilibria between 'homogeneous masses' or 'phases.' A 'homogeneous mass' may be defined after Gibbs as a mass which is capable of 'independent existence' (within limits) and has identical properties including chemical composition along any surface across a sufficiently large number of individual members of the components, so that, the chemical potential of the components and the chemical composition have simultaneously identical values everywhere along any surface in the whole mass. Gibbs defines the term 'phase'⁷ as follows:—

"In considering the different homogeneous bodies which can be formed of any set of component substances, it will be convenient to have a term which shall refer solely to the composition and thermodynamic state of any such body without regard to its quantity or form. We may call such bodies as differ in composition or state, phases."

A good deal of discussion is to be found in the literature as to the meaning of the word 'homogeneous' as used in chemical thermodynamics in connection with the question whether colloids are to be regarded as 'one phase' or 'poly phase' systems. Gibbs defines it as follows:—

"By homogeneous is meant that the part in question is uniform throughout, in chemical and physical state."

Heterogeneities arising out of molecular structure of matter do not prevent any system from being a 'phase' in the Gibbs sense so long as the chemical composition and chemical potential are both identical throughout the mass across any surface, (on a statistical basis) and *the mass is a 'body.'* This latter condition is implied in the expression 'capable of independent existence' and has been interpreted in text books as 'being bounded with surfaces and being mechanically separable.'³

In a recent article Buchner discusses the significance of the term 'phase'³ as follows:—

"The most important point is heterogeneity: in fact, we find many authors stating that a system consists of two phases, because it is heterogeneous. Here confusion arose; it might have been avoided if one had generally realized that the word heterogeneous has only a relative and not an absolute meaning. In the definition of the idea phase, it has therefore to be taken in a relative sense, as has been already clearly explained by Bakhuis Roozeboom and Perrin. Thus, a phase is a part of a system in which definite values may be assigned to the variables determining the state of the system, as pressure, temperature, concentration. This can only be done, if such a phase contains a very great number of molecules, either at one

moment or within a very short time, and if the velocities of these molecules are distributed according to Maxwell's law. Of course these definitions are entirely thermodynamical and for practical use other ones have been introduced. Wilhelm Ostwald and Findlay consider phases to be different portions of a system, each in itself homogeneous, but marked off in space and separated from the other portions by bounding surfaces. It is significant that both authors felt the need of adding the last phrase, to which Findlay joins in addition the words 'mechanically separable.' They clearly intended to give the name phase only to parts of certain dimensions and to exclude the possibility of considering one molecule as a phase."

Buchner³ treats at length the question whether colloids are a 'one phase' system, or a 'polyphase' system and concludes as follows:—

"The preceding demonstration will have made it clear that both theories are equally acceptable. No cogent reasons have been found whereby either of them could be proved, either for all colloid systems, or for a certain group. We therefore cannot declare a colloid to be a one or to be a two phase system; we ought to say it is both. How we shall regard it in any given case, depends on the kind of problem we are investigating. We must in each case choose the most appropriate conception. It is certainly not useful, though theoretically possible, to treat coarse suspensions as one phase systems, nor is it suitable either to consider egg white or rubber solutions as two phase systems."

The above extract shows the difficulties in borderland cases and we shall try to get some definite conception of the 'phasal' relationships in colloids.

Structure of Phases. In chemical thermodynamics the energy of a system is taken to be a function of the following independent variables; the concentrations of the different 'components'^{3a} (i.e., the minimum number of molecular species having ordinarily an invariable average mass irrespective of their nature which would define unequivocally the chemical composition of the system in thermodynamic equilibrium) and pressure and temperature, the two external variables.

According to Gibbs then a 'phase' must be so characterised that its chemical composition and the chemical potentials of its molecules have an identical value at all regions in it (of course, on a statistical basis). Now the components and the two external variables determine unequivocally the chemical potentials only for fluid phases where *ordinarily* the internal structure, or, the arrangement of the 'components' is unequivocally determined by the concentrations of the components. But in the case of solid systems this is not so. Each crystalline system has its characteristic structure and consequently the chemical potentials are characteristic of the particular structure

(the concentrations of the components and pressure and temperature remaining identical). Even in the case of liquids, crystalline liquids illustrate the above effect of differences in structure. We have a very interesting case from the present point of view in the different inherent structures of soap solutions as shown by MacBain.⁹ Baker has, besides, shown that the chemical potentials of the components may have different values depending on the degree of intensive drying (the temperature retaining an identical value). In this case probably it is more a question of the number of components (such as may result from a want of thermodynamic equilibrium between some of the different polymers or isomers which will increase the number of components) than of the structure. At any rate in usual chemical systems the question of structure as affecting thermodynamic potentials for identical chemical composition is not an independent variable for *isotropic* gases and liquids and should be considered as an independent variable only in the case of solid systems. Thus a solid substance can be called a phase so long as it has a definite structure, besides an identical chemical composition and chemical potential of its components throughout its mass. Now in the case of solid phases that we meet with in usual chemical systems the *possible structures of a solid of constant chemical composition*, (that is, the possible forms of the solid phases) are defined by the nature of the components. Also the order of their thermodynamic stability is definite for particular values of pressure and temperature.

Inherent structures of phases.—We shall call these different, structures, or, the possible forms of the solid thus defined '*inherent structures*' because in all these cases it is not necessary to consider additional independent variables arising out of changes in mass, number, or concentration of the components. Size, shape and relative positions of the individual members of the components are innate characteristics of each possible structure.

Interfaces and phasal relationships in colloids.—If we keep in view this definition of '*inherent structures*' it becomes easy for us to *define interfaces*, and to discuss the phase relationships in colloidal systems without confusion. *An interface may be defined as a 'phase boundary' after Gibbs.* Effect of size and shape of the phases on the equilibrium should be correlated through variations in the tension, shape, size, and other properties of the interfaces. This problem was first discussed by Donnan.¹⁰ We ordinarily neglect the interface and its effect on chemical equilibria because fairly wide variations in size and shape of the phases do not affect the state of equilibrium. In the variation of the vapour pressure of a liquid with the size of its drops (spherical) we recognise one additional variable which is distinct from the structural arrangement of the components in the homogeneous masses. Unlike the size and shape of the

phases, the inherent structure as defined above cannot be varied at will within wide limits. Portions of the same homogeneous mass of different shape and size can be in thermodynamic equilibrium, so long as these differences have no effect on the chemical potentials of the components, or, they have identical shape and size. This question has been discussed by Tolman.¹¹ It is possible that, even in the region of variations in shape and size where they affect the chemical potentials, particles having different shapes and sizes may be in thermodynamic equilibrium if there is a difference in their condition, on account of additional variables which make their chemical potentials identical.

The peculiarities of the structure of colloids as a basis for classification.—Such a conglomerate of particles can also be said to possess a structure but the structural units here are portions of phases as defined above and the additional variables are to be looked for in the phase boundary if they be in thermodynamic equilibrium. This distinction of two types of structures is essential for an understanding of the phasal relationships in colloid systems. A diaphragm made of fused silica containing an electrolyte in its pores has a structure which is of considerable significance for many phenomena. It is obviously a 'poly phase' system; because the structure of the mass as a whole is not an 'inherent' one. The concentrations and masses of, what can possibly be visualised as, the 'components' of the mass regarded as a 'one phase' system are themselves variable even though the chemical composition and the external variables remain unchanged. We might designate such structures, as depend on the mass, size and shape of the portions of phases and not on the size and shape of components of invariable mass and structure, as 'colloidal structures' or 'textures.' They are capable of wider variations. If this texture were determined by the size and shape alone of components of constant mass, whose concentrations would be unequivocally defined by the chemical composition of the mass as a whole, such that slight variations would not disturb the equilibrium relations and the system would revert to its former state of thermodynamic equilibrium, then it would be an 'inherent structure.' It is quite possible that in some systems having components with peculiar shape and considerable size there are more possible forms of a phase than we usually meet with in solid or liquid homogeneous systems, but then all these forms will be so many inherent structures. It is therefore a question of facts and not theoretically impossible to ascertain whether a mass of a particular colloidal substance has an 'inherent' or a 'colloidal' structure (that is, whether it is a 'one phase' or a 'poly phase' system). *This difference is not one of degree but of kind and it is connected with the number of independent variables determining the state of thermodynamic equilibrium.*

In chemical thermodynamics we have two mutually exclusive groups of heterogeneous equilibria; (1) systems where

moderate variations of shape and size do not affect the state of equilibrium, (2) where they influence the equilibrium and come in as factors.

On the other hand in colloidal systems (except those which merge into the usual molecular systems), a very important factor called above the 'texture,' or, the mutual relationship of the different bits of one or more phases with their phase boundaries, is of great importance. *In fact we might emphasise this criterion as being characteristic of colloidal phenomena for the purposes of classification.* The importance of the structure of colloids is well recognised and we owe a good deal to the work of Van Bemmelen, Zsigmondy, Wo. Ostwald, Bancroft, Freundlich and others for our present knowledge of the subject. It constitutes along with the electrical and other properties of the interface, one of the fundamental lines of scientific investigation in the study of colloids.

To sum up, the phase relationships in colloids can best be understood and defined, if we remember that a 'component' or each species of chemical molecule has an invariable average mass and if we try to visualise what are the components of the phase and how far the different possible forms of the structure of the mass under consideration are determined for a definite chemical composition, by variables other than the concentrations of the components, pressure and temperature.

Interfaces in chemical thermodynamics.—We now pass on to consider the importance of a study of the properties of interfaces in discussing equilibria in heterogeneous systems and the limitations of the usual thermodynamic treatment when applied to colloidal systems.

Gibbs lays down in terms of the 'chemical potential' the following criterion of equilibrium in heterogeneous systems:—

"The potential for each of the component substances must have a constant value in all parts of the given mass of which that substance is an actual component, and have a value of not less than this in all parts of which it is a possible component."

The interface as such is not considered a phase in the deduction and application of the phase rule in the well-known form:—

$$P + F = C + 2$$

and is left out of consideration when calculating the number of phases. In dealing with such cases as the variation of the vapour pressure of a drop with its size we meet with an extra degree of freedom and the chemical potentials depend on the additional variable, namely, interfacial energy, just as the crystalline form of a solid determines its solubility. If we consider the interface as a 'phase' in ordinary heterogeneous equilibria, where the homogeneous masses are sufficiently large in size and variations in size and shape do not affect the equilibrium;

the inclusion of each interface as a 'phase' must be counter-balanced by a corresponding increase in the number of external variables.¹² Such a procedure will be purely arbitrary as we are introducing additional variables when they do not in fact affect the state of equilibrium.

Non-homogeneous character of an interface and chemical potential. Besides, the interface is not 'homogeneous' in the sense we define a 'phase' as being 'homogeneous.' There cannot be any doubt as to the non-homogeneity¹³ of the interfacial layers perpendicular to the normal to the interface (cp. Van der Waals's theory of the interface and theoretical considerations of Hulshoff and Bakker and the work of Hardy, Langmuir and Harkins). Thus in the electrical double layer assumed to exist around a colloidal particle the sign and value of the electrical density in different surfaces at right angles to the normal to the interface is not constant.

In the literature the 'interface' is often considered as a distinct phase. It also appears that there is some ambiguity as to what to make of the 'interface' if it is not a homogeneous phase in the Gibbs sense. The difficulty seems to lie in not strictly adhering to Gibbs's treatment. The criterion of equilibrium in heterogeneous systems quoted above does not exclude the possibility of the existence of non-homogeneous regions (as the interfaces are) without interfering with the requirements of the phase rule *provided that the chemical potential of each of the components have an identical value everywhere in the whole mass.* In the interfacial layers the potential of an 'actual' component has the same value as in homogeneous regions though they may differ in chemical composition, because of additional variables, (such as, differences in density, internal pressure, the orientation of the molecule, electrical density) which do not operate as *independent* variables in homogeneous masses. So long as the equilibrium is between homogeneous regions or phases (which are well defined bodies) it is not necessary to know separately the chemical potentials of the components in the interfaces, or, to deal with the manner in which these additional variables affect them in the interface, as the conditions for equilibrium are sufficiently given by the chemical potentials of the components in the homogeneous bodies.

In heterogeneous equilibria the various components may occur in *two different relations* to the phases. With reference to a particular phase, some (or, all but one) component may be either an *actual* or a *possible* component of it. A 'possible' component implies that there is a *chemical* interaction though the component is not actually present in it. If, however, we add to the system a substance which does not take any part in the reaction then it is neither a 'possible,' nor, an 'actual' component of the system in equilibrium; that is, it is chemically inert with reference to the particular equilibrium.

Phasal and non-phasal or colloidal interfaces.—Now it is possible to imagine the existence of interfaces not formed as a layer of transition between two well defined 'homogeneous bodies' reacting in chemical equilibrium and we shall discuss their special interest in the study of colloids.

Evidently these are the cases where considerations of solubility of the phases, assumed above to be 'inert,' will fail to explain the equilibrium conditions.¹⁴ For, the chemical potential of the components cannot be unequivocally defined in terms of a definite solid phase reacting in chemical equilibrium. The arrangement of the molecules (*i.e.*, the structure) and the composition in this region may depend on such factors as the conditions of its formation and 'age,' and will be ill-defined and equivocal in contrast to the conditions in the interface between two definite homogeneous phases.

In the case of a solid-liquid interface between well defined 'phases' the structure of the solid side of the interface will be unequivocally defined and we shall characterise such interfaces, as 'phasal' or 'non-colloidal' interfaces. When however a solid phase interacts with the aqueous phase forming ill-defined solid layers, the interface may be characterised as being 'colloidal' or 'non-phasal' and it will show the characteristics of colloidal surfaces such as ageing, hysteresis, etc. The bulk of the original solid phase may be 'chemically inert' in the Gibbs sense because of the intervention of one or more layers of molecules formed by its interaction with the liquid phase. This will happen when chemical interaction between the original solid phase and the liquid phase is not of sufficient intensity. If the solid phase be reacting in chemical equilibrium the conditions in the interface become well defined and the interface loses its 'colloidal' though it will have the usual non-homogeneous properties of all interfaces.

Even when the interface has a 'phasal' character it may be difficult to determine the solubilities of the *actual* and *possible* components of the solid phases and a knowledge of the conditions of the interface would be a great help in understanding various factors influencing the equilibrium.¹⁵ In the case of equilibria between 'colloidal' or 'non-phasal' interfaces and liquid phases, solubility considerations of the original phase will not be a guide but will have, however, a value as showing the type of interface formed by the interaction of the solid phase with the liquid. On the other hand considerations of the electrical condition and other characteristics of the interface, which can be experimentally investigated, will give us most important information regarding the equilibrium condition.⁸ There is of course always the additional theoretical interest of understanding the conditions in an interface.

Interaction between ions in solution and in an interface.—In interfaces containing an electrical double layer the structure of

the solid side of the interface, the concentration of the components and the electrical density are the most important factors influencing the chemical potentials in that region and it becomes easy to understand the effects of the conditions of formation, of the valency, of the mobility of ions and of non-electrolytes in determining the intensity of action of ions which do not react strongly with the solid phase.¹⁶

To explain electro-kinetic effects it is necessary to postulate the existence of diffusible and non-diffusible ions. This distinction signifies that the latter ions are constituents of the non-aqueous phase.* The equilibrium of the non-diffusible ions is governed by their thermodynamic potentials in the non-aqueous phase, in the interface and in the solution, while the equilibrium of ions which are present wholly in a diffusible state may be looked upon as being simply governed by their thermodynamic potential in the interface and in the solution. *We are assuming that these diffusible ions are not constituents of the non-aqueous phase and do not react with it in the chemical sense.* In such cases no useful purpose is served by introducing considerations of solubility of the constituents of the non-aqueous phase.

In many instances † the same ion is in part in a diffusible state and in part in a non-diffusible state, though the bulk of the non-aqueous phase does not contain these ions. Consequently between the bulk of the non-aqueous phase and the liquid side of the interface there are in such cases one or more layers of molecules containing the so-called diffusible ion in a non-diffusible state. A colloidal particle whose charge is partially decreased by the adsorption of oppositely charged ions from an electrolyte, of which the ions are not constituents of the dispersed substance, must be assumed to have such a layer on the solid side of the interface. Obviously the solubilities or thermodynamic potentials of the ions in a new phase, probably in most cases in a sort of solid solution, are the relevant factors.⁸

The want of a clear understanding of the above implications of the classical chemical theory and of the peculiarities of the interface have led several investigators to postulate close chemical relationships, for example, between the solubility product of possible pure phases and the coagulating capacity of the corresponding cations. Thus it has been claimed¹⁷ that

* The term "non-aqueous" phase is used here loosely to designate the phase, as ordinarily understood, other than the bulk of the solution and the liquid side of the interface. It is not denied that water molecules may be present in it.

† Many colloidal particles adsorb ions of both signs from the solution. These adsorbed ions are non-diffusible i.e., "fixed" on the surface and need not necessarily be either *actual* or *possible* components of the bulk of the colloidal particle.

such a relationship is supported by the observation that the coagulating capacities of cadmium, lead, zinc, nickel and manganese ions on a cadmium sulphide sol run parallel to the solubility product of the corresponding sulphides. It is well-known that for colloidal solutions of diverse chemical substances (e.g., arsenious sulphide, colloidal sulphur, gold, silver, platinum, copper ferrocyanide, etc.), the coagulating power of the simpler inorganic cations is in the order $\text{Th} > \text{Al} > \text{Ba} > \text{Sr} > \text{Ca} > \text{Mg} > \text{Rb} > \text{Cs} > \text{K} > \text{Na} > \text{Li}$. This would mean contrary to experience that we have a similar regularity regarding the solubility product of the corresponding series of salts of these cations. (The same series is observed also as regards the effect of cations to liberate acids from different chemical substances; silicic acid, humic acid, manganese oxides, arsenious sulphide.)¹⁸ Moreover in the above instance the particles no longer consist of cadmium sulphide but must also contain the sulphides of cadmium, lead, zinc, nickel and manganese respectively (cp. the colour changes accompanying the coagulation of arsenious sulphide by silver, mercury or lead ions) and *the relative order of the solubility products of the pure salts may not remain unaltered when they are in a state of solid solution having a different molar composition in each case.* One might also note that the conception of solubility product implying equilibrium of two ions between electrically neutral phases is being extended to the case when one of them is on the surface and the other is in the solution. If this point of view were true the coagulating concentrations of these ions will be in the same *ratio* for all colloidal sulphides.

These discussions signify that the capacity of the diffusible ions to become fixed on the surface depends on the corresponding solubility product and imply that the fixed ions diminish the "concentration" (or the number per unit area) of the free sulphide ions on the surface which determine its free charge. But the concentration of the diffusible ions of opposite charge also decreases as the interface as a whole must be electrically neutral and the product of the concentration (or number) of the free ions of both sign cannot remain constant. In the case of polar precipitates ions of both sign are present in a non-diffusible state even in a "neutral" surface and the dissociation or the neutralisation of the ions in excess cannot be discussed independent of the total number of such ions on the surface and the less we speak of *solubility product of ions in an interface* the better.

Such considerations are misleading for another reason. Duclaux, Michaelis and Pauli among others have for a long time attempted to explain the behaviour of these colloids on the basis that the charged colloidal particles are to be regarded as polyvalent ions of microscopic size. It also happens that these same authors and other supporters of this view

speak of the electrical charge as originating from the electrolytic dissociation of molecules on the surface and of changes in their degree of dissociation. One might point out the confusion in ideas involved in such statements as the process of coagulation is not in any way analogous to the precipitation of a polar solid when its solubility product has been exceeded. Numerous experiments show that there is a gradual change in the potential of the electrical double layer (or, one may say, of the density of the electrical charge) on the surface before coagulation takes place. The supporters of the above mentioned point of view consider that diminution in charge results from suppression of the dissociation in stages of a complex salt of which the charged colloidal particle is a constituent. In the case of an electrolyte a decrease in the degree of dissociation is distinct from exceeding the solubility product. If the charged colloidal particles and the associated electrolytic ions are the ions whose solubility product is being exceeded, then we must conceive of a thermodynamic equilibrium* between the coagulum and such ions—a position which has only to be stated to be dismissed as untenable.

It is interesting to note that Michaelis¹⁹ has recently stated that a purely chemical point of view is untenable and that the laws of mass action cannot be applied to these cases.

We shall now refer to an interesting case of an interaction of ions in the interface with those in solution where the equilibrium conditions are exactly the opposite of that deduced from considerations of solubilities. This happens when hydrated silica is in contact with solutions of barium and calcium chloride respectively. If it were an ordinary equilibrium between solid calcium or barium silicate and the solution, as has been suggested by Joseph,²⁰ the equilibrium concentration of hydrogen ions would be greater for the calcium than for the barium salt as calcium silicate is more insoluble than barium silicate but the reverse is observed to be the case. There is therefore no alternative but to recognise the existence of an equilibrium between the interface and the bulk of solution of a type not governed by such considerations. The cause of this behaviour is probably that the cation is retained in or near the solid in a state which is different from what we understand by solid calcium silicate. It is possible that it is held near one of the non-diffusible ions by electro-static forces with a layer of the solvent intervening between them.¹⁸

* If colloidal solutions are regarded as two phase systems, the interface should be regarded as being non-homogeneous. If they are considered as a single phase the colloidal particles are evidently being assumed to behave as "true" polyvalent ions and the question of an interface does not arise.

C. THE SURFACE DISSOCIATION THEORY AND THE THEORY OF ION ADSORPTION.

The chemical theory attributes the origin of the electrical separation in the interface to a sort of dissociation of molecules in the surface in analogy to electrolytic dissociation. Apart from the remarks in the previous sections the dissociation of a molecule into two parts, one of which is in a (non-diffusible) solid, the other is in a (diffusible) liquid state, is in itself, a conception foreign to classical electrochemistry. *It is not the dissociation of neutral molecules on the surface, but the 'fixation' of ions on the surface which is most important in determining the electrical properties of colloids and the interactions between the surface and the ions in the solution.*

For a comparison of the relative advantages of these two points of view it is necessary to consider all the various groups of phenomena including interchanges of ions and the electrical conditions of the interface, in which the interfacial layer plays a part. For a complete understanding of these facts it is necessary to form a clear conception of the distribution of ions in the interface and of the nature of interchange of ions between the interfacial layer and the solution. It has the additional advantage of bringing within its scope such other problems as the nature of the electrical factors responsible for the so-called electro-kinetic phenomena, the variations in the sign and magnitude of the charge of colloidal particles under different conditions and allied problems.

If we take the case of a well investigated colloid *e.g.*, copper ferrocyanide we see that the dissociation of molecules of potassium ferrocyanide and not that of copper ferrocyanide molecules on the surface is responsible for the electrical charge. In that event we have first to assume that there are neutral molecules of potassium ferrocyanide on the surface. Secondly that these dissociate in part such that an excess of the ferrocyanide ions remains anchored to the surface but the potassium ions are free to move. Thirdly as is known in a number of instances, one has to explain why a considerable amount of the oppositely charged ions (alkali metal cations in the present case) also remains fixed on the negatively charged particle even when its concentration in the solution is low (cp. MacBain's work on soaps).

The surface dissociation theory lays undue stress on the dissociation but overlooks the main factor of an excess of ions of one sign on the surface. If we consider the well known work of Lottermoser on silver salts we find that the dissociation of the surface molecules has very little to do with the electrical charge. The particles may be charged positively or negatively according as what constituent ion is in excess in the solution. In this case it is undoubtedly not a question of dissociation at

all of surface molecules but a *question of 'fixation' or 'adsorption' of ions on the surface.* Where the 'active' electrolyte is neither an acid nor a base it serves no useful purpose in assuming that we are dealing with the dissociation of neutral molecules of strong electrolytes present on the surface. Perhaps the fact that such colloidal micelles (apart from the freely moving ions associated with them) carry with the negative current a considerable amount of alkali metal cation has a lot to do with the prevalence of the idea of dissociation of neutral molecules on the surface, but here also the stress should be laid not on the 'dissociation' but on the 'fixation' on the surface. A more useful standpoint²¹ consists in a modified extension of the views of Freundlich and Langmuir which gives a definite picture of the electrical double layer. The existence of an excess of ions of one sign 'fixed' on the surface should be made the starting point. The 'fixation' may be due to the operation of chemical valences, to lattice energy or to more or less ill-defined forces such as those responsible for the term 'a' in Van der Waals's equation in which cases it has been termed 'primary' adsorption. The 'fixation' may also be the result of purely electrostatic forces between 'solvated' ions fixed on the surface by 'primary' adsorption and 'solvated' ions in solution carrying an opposite charge, in which case the process has been termed 'electrical' adsorption. Chemical relationships are not at all denied and should be kept in view.¹⁶

Another great objection to the surface dissociation theory is the difficulty of accounting for the reversal in the charge of colloids by polyvalent ions of opposite charge at low concentrations. Here again the degree of dissociation is not of any help as we are again dealing with the 'fixation' of ions. A purely chemical point of view would ascribe the reversal to 'complex' formation and assume in many cases formation of 'fictitious' complex ions just to account for the facts. Formation of stable 'complex' cations containing the alkaline earth metals at concentrations as low as $N/300$ has to be assumed against chemical experience.

It has been observed²² that there is an increase in electro-osmotic flow through copper oxide at low concentrations of the chlorides of the alkali and alkaline earth metals similar to the well-known increase observed by Powis and by Ellis in the case of negatively charged surfaces. But unlike the latter the rate of osmosis is the same for these chlorides at equivalent concentrations. The increase in the positive charge cannot be attributed to chemical action of chlorine ions, for, then the charge would decrease. Nor can it be attributed to that of cations as all the chlorides have the same effect at low concentrations. Very probably the hydroxide ions fixed on the surface are displaced by chlorine ions as a result of the high concentration and weaker adsorption of the latter.

The interchange of hydrogen or hydroxyl ions between the solution and the interface likewise shows the defects of the surface dissociation theory. Some neutral salts at very low concentrations increase the charge of a colloidal solution (or a precipitate) as measured by electro-osmotic flow or cataphoretic migrations which reaches a maximum. As the concentration is increased the charge diminishes, becomes reversed in sign, rises again to a maximum and then again decreases.²³ Hydrated manganese dioxide and copper oxide²³ have respectively a 'negative' and a 'positive' charge in contact with water and show such a behaviour. According to the surface dissociation theory the anion and the cation respectively must be non-diffusible in the two instances, the diffusible ions being hydrogen in one case and hydroxyl in the other. A reversal of the charge by divalent cations (barium) and anions (sulphate) respectively has been observed. According to the surface dissociation theory it shows that complex salts have been formed which now dissociate in such a manner that the non-diffusible (or diffusible) ions are of opposite sign to what they had before. But we find that even after the reversal there are in the interfacial layer hydrogen ions (or hydroxyl ions, respectively) and their concentration in the solutions goes on increasing in the same manner as before on still further increasing the concentration of the neutral salt.

We shall attempt to picture the possible reactions from the chemical point of view in the case of copper oxide. The liberation of the free alkali must be the result of the formation of an insoluble salt with sulphate (a 'basic' sulphate). To explain the variation in the charge including reversal in its sign, we have to assume that as the concentration of the sulphate increases the following chemical changes take place:—(1) At low concentrations 'complex' cations containing the alkali and alkaline earth metal ions are formed such that the product of the free valencies and the number of additional complex ions is greater than that of the original non-diffusible ions, whose place they have taken, or, that the *more dissociable copper sulphate* molecules are being formed on the surface or both. (2) We have next to assume that undissociated molecules of copper sulphate (or of a 'basic' sulphate) are being formed on the surface resulting in a diminution in the charge and liberation of alkali. (3) We have next to assume that a complex salt of potassium sulphate with the oxide (or the 'basic' sulphate) is being formed on the solid surface such that the whole complex excepting the potassium ion is negatively charged. But as has been stated above the concentration of free alkali in the solution continues to increase with the concentration of the sulphate. Evidently it must be further assumed that the formation of the complex anion goes on along with the formation of the basic sulphate. (4) At still higher concentrations the degree of dissociation

of the complex must again diminish. Chlorides and nitrates do not show this reversal within the concentration region studied. We see that sulphate ions or more generally polyvalent ions of opposite sign have a marked capacity of forming complex anions. An identical explanation has to be postulated for the liberation of acids from acidic oxides and other substances by alkaline earth metal ions. Apart from the arbitrary nature of assumptions as to the formation of definite complex ions by atoms held together by chemical valences one might ask the question why does the complex remain fixed on the surface and why is it formed so readily with polyvalent ions of opposite sign.

On the other hand it is possible to conceive that oppositely charged ions are held together simply by electrostatic forces with a layer of the solvent molecules intervening between them. There is in fact strong evidence to show that this is at least equally probable. The above assumptions are however not sufficient for our purpose. We have also to make such suitable arbitrary assumptions regarding their solubilities as would explain the equilibrium between the ions in the surface and those in the solution. Since we know very little of the complex itself or of its solubility it is futile to discuss the equilibrium conditions on this basis. As against the shortcomings of the purely chemical theory the adsorption theory⁸ gives a fairly consistent physical picture of the distribution of ions in the double layer and of the manner of interchange of ions and correlates them.

Acidoids, Basoids, Saloids, and Ampholytoids: On chemical analogy Michaelis has attempted to classify colloidal surfaces reacting with ions in solution as 'acidoids,' 'basoids,' 'saloids' and 'ampholytoids.' His idea is to correlate the nature of the interaction of ions in solution with the chemical nature of the non-aqueous phase. While there is some sense in this classification in the instances just quoted there are other cases which do not warrant an exclusive stress on chemical relationships. Apart from the question of equilibrium conditions discussed above this classification does not afford an explanation for several well-known reactions. Bartell and Miller²⁴ have recently shown that neutral inorganic electrolytes in contact with *active charcoal* develop an alkaline reaction. But it also develops an acid reaction with electrolytes containing particular organic cations. Ogwa²⁵ has further shown that 'ash free' charcoal can develop an acid, alkaline or neutral reaction in contact with the same neutral inorganic salt depending on the preparation and 'activation.' He also shows that there is a close relationship between the electro-kinetic behaviour of the charcoal and its capacity to adsorb acid or alkali. Kolthoff²⁶ has reviewed the subject and concludes that the most suitable explanation of hydrolytic adsorption is to be found in the alteration of the interfacial tension. While this explanation need not be accepted in the form suggest-

ed there is no doubt that active charcoal cannot be included in any of the classes suggested by Michaelis,¹⁹ as with the same electrolyte different samples show different behaviour. Another observation is very significant. In the precipitation of barium sulphate²⁷ by mixing solutions of barium chloride and potassium sulphate either an acid or an alkaline reaction is respectively developed depending on whether barium chloride or potassium sulphate is in excess. In all these cases attention should be fixed more on the conditions in the interface, than on the chemical character of the mass as a whole, as a clue to an understanding of the reaction. These observations cannot also be explained by simple considerations of changes in surface tension.²⁶ According to Gibbs and Freundlich a capillary active substance which increases the interfacial tension should have an excess concentration in the interface but it does not follow that it must be fixed on the solid side of the interface. This distinction which is not contemplated in the usual treatment is necessary to account for the observed relationships^{8,25} between the electro-kinetic effect and the interchange of ions. The theory of electrical adsorption of ions⁸ postulates this relationship and it also explains the effect of non-electrolytes²⁶ on the adsorption of ions through their influence on the dielectric constant, mobility, the activity of ions and on primary adsorption. Chemical considerations, which overlook the peculiar conditions in the interface, also fail to explain negative adsorption observed with charcoal.²⁸

D. THE ELECTRICAL CHARGE OF COLLOIDAL PARTICLES.

In the explanations suggested to account for electro-kinetic phenomena the same rivalry is noticeable between physical and chemical schools of thought. On the one hand we have the Quincke-Helmholtz theory²⁹ of the electrical double layer and on the other hand the point of view that the colloidal micelle can be treated as an electrolytic ion. The electrical double layer according to current notions consists of a 'fixed' and a 'mobile' sheet of ions. McBain³⁰ has recently quoted observations which he considers prove conclusively the untenability of the Helmholtz theory. His objections amount in effect to this; that the colloidal particles have mobilities comparable to those of electrolytic ions and that cataphoresis and the electrical migration of ions are fundamentally identical in nature. Wintgen³¹ has pointed out that there is no insuperable difficulty standing in the way of the Helmholtz theory and the contentions of McBain can be easily accounted for. While Wintgen is right so far as the main proposition of the validity of the Helmholtz theory is concerned, it seems to be generally overlooked that the flow of liquid in electro-osmosis must be reinterpreted in terms of the

motion of ions and McBain has rightly emphasised this aspect.

Here also we see the same gradation from a chemical molecule to a coarse particle. But the migration of ions as also cataphoresis is essentially a problem for the physicists, and while we might emphasise with Smoluchowski³² that the two processes are fundamentally correlated there is no justification for concluding that an ion and a colloidal particle are identical from the chemical point of view. We have only to consider the mutual precipitation of colloids and protective action to realise this.³²

LADIES AND GENTLEMEN,

I have tried in the short space of an hour to present before you the fundamental basis of the study of colloids. I am fully aware of the imperfect nature of my exposition and specially of the short-comings of my manner of presentation, and I must thank you for your indulgence in patiently suffering this infliction. When I finished writing this address and read it over I imagined myself exchanging places with members of the learned gathering before me, and that was sufficient to convince me of the very real nature of your sufferings. But I also felt that the privilege, that you have granted me and for which I thank you, carried with it the imperative duty of delivering an Address, and that good or bad I had to do it. I thank you once more for your kind indulgence and assure you that it is a relief to resume my seat.

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Section of Chemistry.

Abstracts.

1. Photo-chemical reaction between tungstic acid sol, glucose and hydrogen peroxide.

J. L. MUKHERJEE and J. C. GHOSH.

The paper deals with the mechanism of the photo-chemical reaction between tungstic acid sol, hydrogen peroxide and glucose in aqueous solution. Tungstic acid sol was prepared by the addition of HCl to sodium tungstate. HCl concentrations were always in excess so as to prevent the independent reactions between H_2O_2 and glucose. The reaction is monomolecular with respect to H_2O_2 for constant concentration of sodium tungstate. The monomolecular constant increases as the concentration of HCl diminishes and is independent of the conc. of glucose. For change in the conc. of tungstic acid sol, keeping the initial conc. of other substances same a maximum value for the constant is obtained which is explained from theoretical considerations. The temperature coefficient of the reaction between 30° and 40°C is 1.3. A slight induction period is observed which is not followed by any after-effect phenomenon.

2. On the effect of X-rays on colloidal solutions.

S. S. BHATNAGAR, K. G. MATHUR, R. S. GUPTA and
K. N. MATHUR.

Colloidal solutions of gold, silver, copper and ferric hydroxide have been exposed to X-rays obtained from a Coolidge tube. Exposures were given extending over several hours. Migration experiments failed to show any change in the density of charge of the particles. Precipitation values obtained in the case of gold sol (protected), ferric hydroxide sol positive, copper sol (protected), negative copper sol (protected) showed no change while in the case of silver evidence obtained indicates slight peptisation. Colour changes have also been studied. An explanation has been attempted to account for these as well as the recent experiments of Crowther and Fairbrothers.

3. Effect of light on colloidal solutions: an explanation for the mechanism of coagulation by light.

PANNA LAL and P. B. GANGULY.

A number of coagulation of colloidal solutions by means of light has been studied with a view to getting an explanation for the mechanism of coagulation of colloids by light. On the basis of the experimental results it is suggested that coagulation is due in most cases to slow chemical reactions taking place in the colloidal solutions. The effect of light is to catalyse these reactions.

4. Studies in photo-chemical reactions.

N. A. YAJNIK and H. L. UPPAL.

The temperature coefficients of certain photo-chemical reactions in different media have been studied. The following conclusions have been arrived at:—

1. No definite relationship could be traced between the dielectric constant of the medium and the velocity constant of the temperature coefficient of the reaction.

2. Plotnikow's generalization regarding the temperature coefficients of photo-chemical reactions was not found to hold good.

3. Von Halban-Dhar rule was not strictly followed by the reactions studied.

5. The effect of magnetic fields on certain chemical reactions.

S. S. BHATNAGAR, K. N. MATHUR, and R. N. KAPUR.

The effect of an external magnetic field has been studied with several chemical reactions. Three kinds of reactions have been found :—

1. Those in which the velocity is accelerated;
2. Those in which it is retarded; and
3. Those in which it has no effect.

From a study of the magnetic properties of the reacting molecules it has been found that the velocity is increased in those cases where the sum of the molecular susceptibility of the reactants becomes greater as the reaction proceeds and retarded where it decreases.

6. A new magnetic balance.

S. S. BHATNAGAR and R. N. MATHUR.

On the principle of the micro-balance a very sensitive new magnetic balance has been constructed. The change in the susceptibility of a specimen can be detected by the shift produced in interference rings. This balance has been specially designed for the study of very minute changes in magnetic susceptibilities.

7. The magnetic susceptibilities of certain isosteric ions.

S. S. BHATNAGAR and S. L. BHATIA.

In this paper the work done in the previous paper has been extended to isosteric ions. The apparatus which in all essentials is a modified form of Bauer's and Piccard's apparatus for the determination of the magnetic susceptibilities of solutions has been described. From the values of the diamagnetic susceptibilities of solutions, the values for the diamagnetic susceptibilities of solutes, and consequently of the respective ions have been determined and compared with the values calculated on the basis of the equation :

$$\chi_m = -2.85 \times 10^{10} \sum (K r_1)^2.$$

It has been found that the agreement between the experimental and the calculated values for the isosteric ions of the type $\overset{+}{K}$, $\overset{++}{Ca}$, $\overset{+}{Na}$ and $\overset{++}{Mg}$, $\overset{+}{NO_3}$ and $\overset{++}{CO_3}$, $[SeO_4]^{--}$ and $[AsO_4]^{--}$, $\overset{+}{SO_4}$ and $[PO_4]^{--}$ and $\overset{+}{ClO_3}$ is very satisfactory.

8. The magnetic susceptibilities of certain molecules having an odd number of electrons.

S. S. BHATNAGAR and S. T. BHATIA.

In this paper the previous work done in support of the theory of G. N. Lewis has been reviewed. The determinations of the diamagnetic susceptibilities of chlorine dioxide adsorbed over silica and charcoal, of iodine dioxide, and of copper hydrogen arsenite have been made. It has

been found that chlorine dioxide is paramagnetic both when adsorbed over silica and charcoal, iodine dioxide diamagnetic whereas copper hydrogen arsenite is strongly paramagnetic. The probable structure of iodine dioxide as a basic iodine iodate has been discussed.

9. The equilibrium constant in the dehydration of methyl alcohol with sulphuric acid as catalyst.

N. G. GAJENDRAGAD.

In continuation of investigations with potassium alum and silica catalysts, the dehydration of methyl alcohol to methyl ether has been studied by passing (1) absolute methyl alcohol, (2) methyl-ether+water and (3) a mixture of nearly the same composition as the equilibrium mixture through sulphuric acid. The value of the equilibrium constant at 130° is 40 corresponding to 92.3 per cent. etherification of the absolute alcohol. Calculations have been made connecting the equilibrium constant with the specific heats of the reacting gases.

10. Reaction rate between ions at great dilutions.

A. N. KAPPANNA.

The paper deals with the kinetics of the reaction between sodium thiosulphate and sodium monobromacetate. Velocity measurements have been made at different ionic concentrations at 30°, 40° and 50°C. The kinetic activity factor increases with increase in ionic strength. The Debye-Huckel limitation law quantitatively predicts the variation of the reaction rate between ionic strengths 0.0025 u and 0.015 u.

The temperature coefficient has been found to have the same value at all ionic concentrations.

11. Action of nitric oxide on potassium permanganate and dichromate solutions of varying acidity.

N. VENKATA NARASIMHACHAR and C. SITARAMA RAO,
Mysore.

The rate of reaction of pure nitric oxide with potassium permanganate and dichromate solutions of varying acidity has been measured at a temperature of 25°C. The gas was passed through the solutions at a rate of 50 c.c. per minute. The permanganate and dichromate solutions were 0.05 normal and were rendered acid with sulphuric acid.

When acidity of permanganate solution was less than 0.1 N a precipitate of manganese dioxide was obtained. For 3.75 N acid, in solutions of equivalent strengths of the two oxidising agents, reaction velocity with permanganate was 4.3 times that with dichromate. The effect of acid on rate of reduction of dichromate has been quantitatively investigated.

12. Period of induction in chemical reactions. Part II.
Action of hypophosphorous acid on copper salts.

P. NEOGI and SHYAMACHARAN MUKHERJEE.

There is a distinct period of induction in the interaction between hypophosphorous acid and copper sulphate and the same acid on cupric chloride when cuprous hydride is obtained in the first case and cuprous chloride in the second case. The same kind of induction is observed when a solution of cupric hypophosphite, obtained by the interaction of thallium hypophosphite (hitherto unknown) and cupric chloride, is heated, cuprous hydride being obtained when heated alone and cuprous

chloride when heated with excess of cupric chloride. The period of induction

- (1) depends on the concentration of the solutions,
- (2) decreases with increase in temperature,
- (3) increases in the presence of alcohol, glycerol, chloride, sulphates, nitrates, oxalates, citrates, tartrates.
- (4) diminishes in the presence of acids.

The causes which determine the period of induction are :—

- (1) Influence of successive stages in the reaction, one of the intermediate compounds being undoubtedly copper hypophosphite, the other being probably $\text{CuH}(\text{H}_2\text{PO}_2)$, whilst phosphorous and phosphoric acids are formed. Some idea of these intermediate compounds is obtained by the determination of the p_{H} values of the mixture.
- (2) Change in temperature.
- (3) Catalytic influence of added substances.

13. Evaporation of liquids in still air.

H. L. ROY and T. GUPTA.

The rate of evaporation of liquids per unit time per unit surface of the liquid exposed depend on the following factors :—

- (1) Difference between vapour pressure of the liquid and the partial vapour pressure of the same in air, it is important specially in the case of water.
- (2) Temperature difference between liquid and the air.
- (3) Depth of the liquid-level from the top of the vessel; influence of depth varies with the area of the surface exposed.
- (4) Barometric pressure.

Results of experiments for the determination of the magnitude of the influence of the above-mentioned factors on the rate of evaporation within the range of our observations are as follows :—

(1) Grammes of water evaporated per hour per square inch of surface = $\frac{\Delta p}{114}$, p in mm. of mercury.

(2) Grammes of water evaporated per hour per square inch of surface = $\frac{\Delta T}{120}$, T in degrees Fahr.

(3) Rate of evaporation decreases with the lowering of the liquid-level from the top of the vessel. It has not yet been possible to find mathematical expression for this effect.

(4) Up till now all experiments have been carried at almost the same barometric pressure.

Further work on the same and with liquids other than water is in progress.

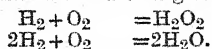
14. Ignition temperature of gases.

H. K. SEN and H. N. CHATTERJEE.

Falk found by igniting mixtures of hydrogen and oxygen by adiabatic compression (*J. Amer. Chem. Soc.*, 1906; 1907) that the lowest ignition temperature is possessed by a mixture in which the two gases are in equimolecular proportions. From this he infers that the most active mixture is given by $(\text{H}_2 + \text{O}_2)$ and not by $(2\text{H}_2 + \text{O}_2)$, and concluded further that in all hydrogen-oxygen combustions, hydrogen peroxide is first formed. He, therefore, considers the reaction between hydrogen and oxygen to be bimolecular which requires the active masses to be equimolecular for maximum velocity. Falk's experiments were conducted

under high pressure (35-40 atmospheres). Dixon who repeated Falk's experiments after introducing several changes in the apparatus found that with increasing proportion of oxygen, the ignition temperature of the oxy-hydrogen mixture decreases, but does not confirm that ($\text{H}_2 + \text{O}_2$) is the most active mixture. In our investigation, soap bubbles filled with mixtures of hydrogen and oxygen in different proportions were fired by touching the bubble with hot points or spirals heated up to definite temperatures by passing electrical currents. It was found that ($2\text{H}_2 + \text{O}_2$) ignited at the lowest temperature, whilst ($\text{H}_2 + \text{O}_2$) ignited at a somewhat higher temperature, the difference in the ammeter reading in the two cases being of the order of 0.02 amperes. This would indicate that under ordinary pressure ($2\text{H}_2 + \text{O}_2$) is the most active mixture, and as such the reaction is trimolecular. This supports Bodenstein's results.

From thermodynamical considerations, under increased pressure the formation of H_2O_2 as suggested by Falk is likely, whereas under ordinary pressure the chance of formation of water is greater:—



By allowing the explosion to take place in the vicinity of starch-iodide paper, no indication of H_2O_2 could be detected. So far, therefore, our results seem contrary to the ordinarily accepted view regarding the course of oxy-hydrogen reaction.

15. True and colloidal viscosities.

N. A. YAJNIK and THAKAR DAS.

The influence produced upon the conductivity of lithium, sodium and potassium chloride by equally viscous solutions of certain colloids and non-electrolytes has been studied. It was found that the influence produced by the colloids was very slight while the monohydric alcohols and acetone produced a very marked effect. The effect produced by sugars and glycerine was intermediate.

16. The effect of electrolytes and non-electrolytes on the transparency of silicic acid gel.

N. A. YAJNIK and L. N. HAKSAR.

In this investigation the effect produced on the transparency of silicic acid gel by dilution and by the addition of small quantities of electrolytes and non-electrolytes has been studied. It was noticed that:—

(a) The gels obtained from dilute solutions were more transparent than those produced from concentrated solutions and (b) in general the addition of small quantities of electrolytes and non-electrolytes brought about a decrease in the transparency of the gel. From among the substances tried the sulphates of lithium, sodium and aluminium, resorcinol, glycerine and sugars were found to be the only exceptions.

17. Peptisation of thorium hydroxide in presence of non-electrolytes.

A. M. PATEL and A. R. NORMAND.

The amounts of non-electrolytes just sufficient to prevent instantaneous precipitation of thorium hydroxide from solutions of nitrate of the metal, when sodium hydroxide solutions—always in amount greater than the amount equivalent to the metal—are added to them, have been determined.

It is found that cane-sugar and glycerol prevent the appearance of the hydroxide of the metal while methyl and ethyl alcohols, urea and acetone even when added in large amounts, do not prevent the formation of thorium hydroxide at all.

The amount of cane-sugar or glycerol required, increases with the amount of the hydroxide peptised. Sugar is found to be a better peptising agent than glycerol.

The amount of cane-sugar or glycerol which will peptise the hydroxide (same amount) decreases with the increase of the concentration of sodium hydroxide, the decrease becoming more marked with increasing amounts of sodium hydroxide.

With increase in dilution of the mixture (the amounts of sodium hydroxide and the hydroxide of the metal being kept constant) the amount of cane-sugar required to prevent the precipitation of thorium hydroxide decreases.

The results incline one to the belief that adsorption plays an important part with the peptisation process.

(Results will be presented.)

18. Kinetics of coagulation.

A. M. PATEL and A. R. NORMAND.

While explaining the non-observance of "slow coagulation" region by workers on coagulation velocity, it has been assumed by Desai (Trans. Faraday Soc., XXIV, 181, 1928; Kolloid Beihefte, XXVI, 357, 1928) that the autocatalytic nature of the coagulation reaction and the "S" shaped curve for the coagulation velocity depend on the concentration of the sol as well as the charge on the colloidal particles. These assumptions have been put to test by further work on the thorium oxide hydrosol.

The coagulation velocity of thorium hydroxide sols of different concentrations (the concentrated sol diluted to different extents) and dialysed to different extents (increasing the sensitiveness of the sol or the charge on the colloidal particles) when coagulated with sodium chloride solutions of different concentrations, has been studied. It is found that with increase in the dilution or the sensitivity of the sol the "S" shaped curves gradually disappear and that the above assumptions are found to be valid.

(Results will be presented.)

19. Relation between purity of colloidal thorium hydroxide and its sensitisation.

A. M. PATEL and A. R. NORMAND.

Sensitisation of colloidal thorium hydroxide dialysed to different extents has been studied by measuring its coagulation velocity when mixtures of an electrolyte + non-electrolytes or non-electrolytes alone are added to it. It is found that an impure sample of the sol (containing an appreciable amount of the peptizing agent) is not sensitised by non-electrolytes alone, although some sensitisation is noticed when they are added together with an electrolyte. With the progress of dialysis—increasing the purity of the sol—however, the sol becomes more and more sensitive to non-electrolytes and a fairly pure sample of the sol can be coagulated even by small amounts of non-electrolytes. The following is the order of the sensitising power of the non-electrolytes that have been tried in this connection.

Urea > methyl alcohol > ethyl alcohol > propyl alcohol > cane sugar > acetone.

The results can satisfactorily be explained on the basis of adsorption of non-electrolytes with a consequent lowering of the dielectric constant

at the interface which in turn will decrease the charge on the colloid particle or make the sol more sensitive.

20. Stabilising effect of sodium tungstate on the coagulation of tungstic acid sol by hydrochloric acid.

J. L. MUKHERJEE, Dacca.

In the coagulation of tungstic acid sol by the addition of HCl to sodium tungstate it has been observed that if the conc. of HCl is kept constant and that of sodium tungstate varied, the rate of coagulation increases as the conc. of sodium tungstate diminishes. This rate is measured by the interval of time that elapses between the mixing of the two solutions and the first appearance of visible turbidity. This phenomenon has been explained by the stabilising effect of sodium tungstate molecule. When very small concs. of HCl and sodium tungstate were used the particles formed were almost granular and much finer and underwent the allotropic modification from white to the yellow variety.

21. Coagulation of colloidal titanate hydroxide.

S. K. MAJUMDAR.

Titanium oxide hydrosol behaves as a typical positively charged hydrosol. The coagulation capacity of potassium salts is in the order Ferri > Ferro > Sulphate > Chloride > Nitrate > Bromide. The sol is sensitised on dilution. It is also sensitised in presence of methyl and ethyl alcohols towards the majority of electrolytes studied. On ageing the sol becomes remarkably stable against coagulation by electrolytes.

22. The optimum conditions for the formation of silica gel from sodium silicate solutions.

R. C. RAY and P. B. GANGULY.

Although a number of patents have been taken out on this subject, very few actual experimental data on the suitable conditions for the formation of silica gel have been published. The formation of the gel by the action of hydrochloric acid, sulphuric acid, ferric chloride and other electrolytes, has been studied, and the influence of hydrogen ion concentration, temperature, time, and other factors determined. It has been found that it is only within a limited range of hydrogen ion concentration that gel formation takes place.

23. Formation of silicic acid gels. Part I.

R. R. HATTIANGADI.

Formation of silicic acid gel has been studied by the method of Bhatnagar and Mathur and it has been found that the time of setting of the gel depends upon the concentration of the solutions of sodium silicate and ammonium acetate. For the same solution of sodium silicate and with increasing concentrations of ammonium acetate the time of setting of the gels first decreases, reaches a minimum, and then begins to increase. The time of setting has been followed by an optical method and it has been shown that this method is more accurate than the Fleming's method or that suggested by Fells and Firth.

Using the indicator method it has been found that with concentrations of ammonium acetate corresponding to the minimum point or lower, the gels are formed from alkaline mixtures and with higher concentrations of ammonium acetate, from acidic ones. The gels in the two cases are, therefore, formed under different conditions and exhibit various different properties.

An explanation of the formation of the two types of gels has been suggested and it has been shown that it can also be applied to the cases of the formation of the gels from the mixtures of solutions of sodium silicate and acids.

24. Experiments on precipitated manganese dioxide and on hydrosols of manganese dioxide.

M. R. SUBBA RAO.

Precipitated manganese dioxide has been prepared after the method of Sarkar and Dhar (*Z. anorg. Chem.*, 121, 135, 1922) and also in the manner adopted by Ghosh (*J.C.S.*, 128, 2605, 1926). Adsorption of both the cation and the anion with both these precipitates has been studied. Preliminary cataphoretic measurements have been also carried out with positive and negative manganese oxide sols.

25. Measurement of the cataphoretic speed of particles of ferric oxide hydrosols.

J. N. MUKHERJEE, S. P. RAICHAUDHURY, and
A. S. BHATTACHARYA.

Charge measurements with ferric hydroxide sol at different dilutions have been carried out. It has been demonstrated that in order to obtain accurate values of the mobility for this sol, the upper liquid should be of an identical composition with that of the intermicellary liquid in the sol, so that the potential at the colloid-liquid boundary remains constant. It has been shown that the greater the dilution of the sol the greater is the cataphoretic speed.

26. Uranium ferrocyanide sol. Effect of electrolytes and non-electrolytes on its coagulation.

NIRMALA PADA CHATTERJEE.

Dhar and his co-workers have done coagulation experiments with uranium ferrocyanide sols. It has been found that contrary to Dhar's experience both positive and negatively charged sols can be obtained by precipitating the sol in presence respectively of an excess of $K_4Fe(CN)_6$ or $(UO_2)(NO_3)_2$ and then washing the sol till peptisation. With electrolytes having tri- or tetra-valent coagulating ions, both sols show a strong reversal of charge. The coagulating powers of the electrolytes studied show the same order for the negative sol as for copper ferrocyanide sol.

27. On the existence of a critical potential in the coagulation of colloids by electrolytes.

J. N. MUKHERJEE, S. P. RAICHAUDHURY, and
A. S. BHATTACHARYA.

Cataphoretic measurements of different concentrations of arsenious sulphide hydrosol in presence of various concentrations of potassium chloride show that the mobility of concentrated sols first diminishes, and then increases while that of a very diluted sol at first increases and afterwards diminishes with increasing concentration of potassium chloride. There is a final drop in the cataphoretic speed after partial coagulation of the sol, which shows that some irreversible change has set in.

28. Experiments on coagulation of arsenious sulphide sol by electrolytes in presence and absence of arsenious oxide and hydrogen sulphide.

S. N. MUKHERJEE and S. C. GANGOOLY.

Arsenious oxide is known to sensitise arsenious sulphide sol to a certain extent. It has been observed that small amounts of arsenious oxide (as much as 5%) produce a very marked effect. The sensitising effect is not proportional to the concentration of oxide and changes little after a certain concentration has been reached. Experiments were carried out from both sides *viz.*, starting from a pure arsenious acid solution and converting different percentages of this into arsenious sulphide sol, and also starting from arsenious sulphide sol free from arsenious oxide and hydrogen sulphide, and adding to it different percentages of arsenious oxide. Both types of sols show similar sensitising effects but in the case where arsenious oxide is added after preparation of the sol it appears to be stabler than the corresponding sol prepared by the first method.

The effect of bubbling hydrogen sulphide through arsenious sulphide sols has been investigated. A sol free from arsenious oxide and hydrogen sulphide was prepared by mixing equivalent amounts of solutions of arsenious acid and of hydrogen sulphide. Through a portion of this sol hydrogen sulphide was bubbled for 5 minutes and subsequently the excess of dissolved H_2S was removed by passing hydrogen through the sol till on coagulation it gave no test of sulphide with lead acetate. The sol which was treated in the above manner with hydrogen sulphide and hydrogen was found to be considerably stabler than the other one, as shown by coagulation experiments with electrolytes having uni- and bivalent cations. The stabler sol probably contains more hydrogen sulphide.

29. Experiments with purified activated charcoal.

S. P. RAICHAUDHURY.

Pure activated animal charcoal and sugar charcoal have been prepared after the method of E. J. Millar (*J.P.C.*, 30, 1031, 1926) and adsorption of ions are being investigated analytically and also from electro-osmotic experiments.

30. Studies on the formation of periodic precipitates—VI.

L. N. MUKHERJI and A. C. CHATTERJI.

Exhaustive studies on the formation of rings in silicic acid and other inorganic gels have been carried out.

Attempts have been made to produce rings of the following substances with silicic acid as the medium:—

Sulphates of barium and strontium; ferrocyanides, ferrieyanides and cyanides of silver, cobalt, nickel, manganese, copper, barium, zinc, lead, iron (ic).

Rings were obtained with strontium sulphate, ferrieyanides of nickel, manganese and copper; ferrocyanides of silver, nickel, copper and barium.

The effects of the change in the concentration of the reacting electrolytes and of the gel have been also investigated and it has been found that a change in the concentration of the diffusing electrolyte is as effective in ring formation as a change of the solute in the gel. Therefore there seems to be no sufficient justification for Bradford's assumption (*Biochem. Journ.* [14] 29, 1920) that "it is the solute in the gel that is more effective in ring formation," if change of concentration is brought about in the reacting substances.

By decreasing the concentration of the diffusing electrolyte the distance between two consecutive rings is in some cases increased while in others it is decreased.

31. Condition of sparingly soluble substances when formed in presence of gelatine and agar-agar.

L. N. MUKHERJI, J. M. DHAR and A. C. CHATTERJI.

In previous papers (Trans. Faraday Soc. [72] 23, 1926; J. Ind. Chem. Soc. [5] 175, 1928.) it has been proved from electric conductivity and diffusion experiments that AgCrO_4 and AgCl in gelatine exist mainly in the colloidal state.

In this paper experiments have been undertaken to find out the electric conductivity of different concentrations of lead chromate in gelatine and in agar-agar, and silver iodide in gelatine alone at 35°C .

In all cases the observed conductivity is much less than the conductivity calculated on the assumption that the sparingly soluble substances exist wholly as ions.

Bolam and Mackenzie (Trans. Faraday Soc. [67] 160, 1926) showed from their E.M.F. measurements that the amount of silver present in the ionic condition in silver chromate in gelatine is approximately 40 per cent. The concentrations of free silver ions by E.M.F. measurements have been calculated for AgCl and AgBr , and it has been found that silver present in the ionic condition is in all cases very small and is approximately of the same order as the solubility of these salts in water.

The hydrogen ion present in gelatine cannot dissolve either AgCl or AgBr and hence the amount of free silver ion in these cases is much less than it is in the case of silver chromate in gelatine where hydrogen ions exert a solvent action.

32. The adsorption of chromate ion by barium sulphate.

H. R. IYENGAR, Bangalore.

The adsorption of salt solutions by barium sulphate has been studied extensively by Weiser, Mukherjee and others. In the present paper it has been shown that the adsorption of chromate ion by barium sulphate precipitated in acid medium is strong. It is noticed that the adsorbed chromate ion cannot be completely removed by repeated washing with hot dilute hydrochloric acid. The amount of chromate ion adsorbed depends upon the size of the sulphate particles and not upon the concentration of the chromate ion in the solution. Barium chromate is not found to be a constituent of the solid phase. The sulphate precipitate develops acidity on shaking with neutral potassium chloride solution thereby showing that the diffuse layer consists of hydrogen ions. The effect of the presence of various electrolytes and non-electrolytes on the adsorption of chromate ion by barium sulphate is being studied.

33. Adsorption of colloidal solutions and of ions by freshly prepared precipitates.

A. C. CHATTERJI and S. C. VARMA, Lucknow.

In previous papers (Proc. Ind. Science Cong., 1927; Zeit. anorg. Chem., 159, 186, 1927) it has been shown that lead chromate sol stabilised by agar-agar is almost completely adsorbed by a freshly prepared lead chromate precipitate which has been thoroughly washed. In this paper

the adsorption of lead chromate sol stabilised by gelatine and other "protective colloids" has been studied. In the case of lead chromate sol protected by gelatine, the adsorption is less than that when the same sol is stabilised by agar-agar. This is evidently due to the greater protective action of gelatine on lead chromate.

The adsorption of other sols, *e.g.*, hydrous cupric oxide, nickel hydroxide, mercuric oxide and Prussian blue (cf. Chatterji and Dhar, *Chem. News*, 121, 253, 1920; Weiser, *J. Phys. Chem.*, 27, 505, 1923) by their own respective freshly prepared precipitates, has also been studied.

With a view to examine Bradford's adsorption theory of Liesegang ring formation, the adsorption of chromate and lead ions by lead chromate precipitate under different conditions has been studied quantitatively.

The results indicate that there is not enough adsorption of the constituent ion to justify Bradford's theory of the formation of Liesegang rings.

34. Reaction of silver oxide with sulphates and nitrates of alkali metals.

S. P. RAICHAUDHURY and J. BAGCHI.

Purified silver oxide has been treated with various concentrations of the nitrates and sulphates of alkali metals. It has been found that alkali is liberated in each case and the equilibrium concentration of the alkali increases with increasing concentration of the electrolyte added. The sulphate shows some peculiarities.

35. Adsorption and heats of adsorption.—I. Gelatine solutions. II. Methyl alcohol and water mixtures.

J. C. KANE.

The amounts of gelatine adsorbed from dilute solutions by charcoal, silica and hydroxides of aluminium, iron and nickel—moist and dry—were measured refractometrically. It was found that the chemical nature of the adsorbent has a marked effect on the amount adsorbed.

Attempts were made to determine the heat of adsorption of gelatine by measuring the heat developed on wetting these materials with gelatine solutions, but the difference from the heat evolved with pure water was so small that no result could be obtained.

The change in concentration on adsorption and heats of adsorption of methyl alcohol, water and their mixtures when brought into contact with charcoal and silica have been measured.

36. Studies in adsorption from binary mixtures of liquids.

B. S. RAO and K. SUBBA RAO, Bangalore.

Selective adsorption of liquid by finely divided silver from mixtures of carbon tetrachloride and carbon disulphide was investigated. A Pulfrich refractometer was employed for the analysis of the mixtures. Carbon disulphide was found to be selectively adsorbed over the entire range of concentrations. (Similar experiments with silica gel indicated no selective adsorption.—B. S. Rao and H. M. C. Basappa, *Ind. Sci. Congress*, 1928.) In mixtures of carbon tetrachloride and acetylene tetrabromide silver selectively adsorbed the tetrabromide.

The authors suggest that selective adsorption in the above cases is probably related to the fact that silver sulphide and bromide are more insoluble than the chloride.

37. Adsorption of benzol vapour by highly activated bauxite.

J. K. CHOWDHURY and H. N. PAL, Dacca.

Coarsely powdered bauxite is generally preferred as an adsorbent in many industries as this is an extremely hard mineral and can be obtained very cheap. But its capacity of specific adsorption for benzol vapour—particularly in the concentrations in which it generally occurs in coal gas—is very small. It has however been found by the authors that the deposition of certain inorganic gels, particularly of silica gel on powdered bauxite, increases its activity by some 300%—400%. This activated bauxite has much higher adsorption capacity than either bauxite or silica gel and is not chemically or physically changed by sulphuretted hydrogen and other constituents of coal gas and may be revived by the simple process of roasting.

38. The annulment of the liquid junction potential between two concentrations of hydrochloric acid by saturated KCl.

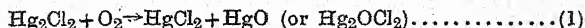
J. N. MUKHERJEE and K. K. KUMAR.

It appears that the annulment is not complete and the resultant potential is not reproducible.

39. The causes of the failure of the calomel electrodes in E.M.F. measurements for hydrochloric acid concentrations below .03 N.

J. N. MUKHERJEE and K. K. KUMAR.

It is well known that the calomel electrode is not applicable for concentrations below .03N (Noyes and Ellis, J.A.C.S., 1917, 39, 2532). It has been suggested previously that the difficulty arises from the dissolved oxygen but no explanation has been given as to what part the dissolved oxygen plays in the matter. It has been shown in this paper that the difficulty is due to a decrease in the concentration of the acid which is correctly represented by the observed E.M.F. It seems that the removal of the acid is connected with the dissolved oxygen in the following manner:—



40. Electrometric titration in alcoholic solutions.

B. H. KRISHNA and M. SREENIVASAYA.

A method is described for the quick titration of alcoholic solutions during saponification or acid value determinations without the use of a potentiometer, using quinhydrone or hydrogen-electrodes. The conditions for the accurate determinations of these constants in highly coloured alcoholic solutions and the utility of the proposed method in routine analysis have been discussed.

41. The action of hydrogen sulphide on chromates. Part I.

H. B. DUNNICLIFF and C. L. SONI.

When potassium chromate is treated with excess of hydrogen sulphide, potassium thiosulphate and pentasulphide, free sulphur and chro-

mium hydroxide are produced. This is in marked contrast with the products of reduction of chromic acid and potassium bichromate by hydrogen sulphide in both of which actions the sulphate group is developed.

The mechanism of the reaction is interpreted in terms of the electronic theory of valency.

42. The action of hydrogen sulphide on alcoholic solutions of mercuric chloride.

H. B. DUNNICLIFF *and* BASANT RATTAN.

Evidence is given of the probable existence of unstable compounds having the formulae HgS , HgCl_2 and 3HgS , 2HgCl_2 in addition to the well known and stable white substance 2HgS , HgCl_2 . Attempts to show that yellow complexes in this series contained vermilion were unsuccessful.

43. The inhibition of certain photochemical reactions by oxygen.

H. B. DUNNICLIFF *and* JANKI NATH JOSHI.

It is shown that the following photosensitive reactions are inhibited by oxygen, ozone or hydrogen peroxide. (1) The action of ammonium oxalate on mercuric chloride; (2) the oxidation of lactic acid by bromine water; (3) the reduction of ferric oxalate to ferrous oxalate and (4) the decomposition of certain silver salts. Some other reactions gave negative results.

44. The action of bromine on strontium oxide and its hydrates.

H. B. DUNNICLIFF, HARNAM DAS SURI, *and* KISHEN LAL MALHOTRA.

Strontium hydroxide monohydrate (prepared by extracting the octahydrate with alcohol) with bromine vapour yields bromide and hypobromite. Moist air causes rapid decomposition of the hypobromite and formation of bromate. Bromine in carbon tetrachloride acts on the monohydrates hydroxide giving first a rapid chemical action (about 40% quantitative) followed by adsorption of bromine until 0.7 mol. of bromine has reacted with 1 mol. of the hydroxide. The dried product contains bromide and hypobromite.

With carbon tetrachloride solution, a preliminary reaction involving 33% of the hydroxide takes place very rapidly. This is followed by a mono-molecular reaction. The rapid preliminary reaction is shown to be equivalent to the change that would have taken place in one hour if the monomolecular reaction had proceeded smoothly from the start.

Insolation favours the formation of bromate.

45. The reduction of aqueous solutions of chromic acid by hydrogen sulphide.

H. B. DUNNICLIFF *and* G. S. KOTWANI.

Preliminary experiments indicated that the green precipitate formed is a basic salt or co-ordination compound containing sulphate. Sulphur separates but no thiosulphate appears in this reaction.

46. The reduction of nitric acid by hydrogen sulphide.

H. B. DUNNICLIFF *and* SARDAR MOHAMMAD.

Solutions containing 5% nitric acid are not affected. Experiments were performed on 43% solutions. The products are sulphuric acid, ammonia, sulphur, nitrous acid, nitric oxide and nitrous oxide. The ammonia is formed in a side reaction. The mechanism appears to be nitric acid \rightarrow nitrous acid which combines with nitric acid to give nitrosic acid ($\text{H}_2\text{N}_2\text{O}_5$) and some nitric oxide. Further reduction gives nitro-hydroxylamic acid ($\text{H}_2\text{N}_2\text{O}_3$) \rightarrow hyponitrous acid \rightarrow nitrous oxide. A remarkable instance of chemical stasis occurs in that a solution containing 23% nitric acid and 15% sulphuric acid whether prepared by mixing or produced in the course of the reduction is passive to the action of hydrogen sulphide.

47. The action of sodium thiosulphate on mercuric chloride.

KISHEN LAL, HAZARA SINGH *and* H. B. DUNNICLIFF.

Attempts to isolate the double or co-ordinated thiosulphates of sodium and mercury have not been successful. The further examination of this problem is proceeding by physico-chemical methods.

48. The volumetric determination of mercury.

H. B. DUNNICLIFF *and* H. D. SURI.

(1) Equal volumes of standard stannous chloride and 25% sodium tartrate are mixed in an atmosphere of CO_2 . The hydrochloric acid present is neutralised with a calculated quantity of sodium bicarbonate and the solution thoroughly mixed in an atmosphere of CO_2 . To this a known volume of mercuric chloride solution is added and the mercury which separates is filtered off into a burette through a specially designed apparatus. An aliquot part of the filtrate is added to excess of hot standard ferric alum solution acidified with hydrochloric acid and the excess of iron determined by means of standard titanous chloride, care still being taken to exclude air.

The second method is identical with the one just described except that the filtered solution is run into an excess of standard iodine and the excess back-titrated against sodium thiosulphate.

An accuracy of 0.2% can be obtained by both the methods using mercury solution N/40 and upwards.

49. A detailed study of the complex salts of the thiocyanates of the bivalent metals (Zn, Ni, Ce, Mn, Cd, Fe^{II}, Cr^{II}, V^{II}, Mg, Be,) with hydrazine.P. B. SARKAR *and* B. K. DUTT-ROY.

Solubility of the complexes in the precipitant, for example, hydrazine and am-thiocyanate is almost zero.

On this is based a new very rapid and accurate method of estimation of Co, Ni, Zn, and Cd.

50. On the chemistry of scandium and its classification with other elements.

P. B. SARKAR.

Chemical and spectroscopical examination of certain Indian minerals—columbite of Gaya District,—beryls and allanites.

51. A study on the preparation and properties of mercuric acetate.

S. N. SHUKLA.

(Communicated by P. S. MacMahon.)

With a view to study the causes of the low conductivity of acetates and mercuric salts, the preparation of pure mercuric acetate was undertaken.

Freshly precipitated mercuric oxide was dissolved in pure glacial acetic acid. In one case, an excess of the acid was added to the wet oxide the whole being warmed on a water bath till complete dissolution had taken place. In the other, dry mercuric oxide was added in small quantities at a time to boiling acetic acid till there was an excess of the oxide (*Beilsteins*, Band II, 113, 1920).

In both cases the products obtained gave reactions for mercurous ions, though the oxide was tested to be free of any mercurous ions.

At present the most suitable medium from which it can be crystallised out, is acetic acid, but it is very difficult to remove the last traces of the acid from the product obtained.

The solid is decomposed if kept exposed to air or in contact with water, alcohol, ether, chloroform or benzene. An aqueous solution of the salt also decomposes, the decomposition is the greater the more concentrated the solution or the higher the temperature.

On the assumption that the substance was all mercuric acetate the conductivity values obtained were in fair agreement with those given by Ley in *Zeit. Phys. Chem.*, [30], 248, 1899, but not with those given by the same author in *Ber.*, [32], 1361, 1899 and in Abegg's *Handbuch der Anorg. Chem.*, Band II, Abt. 2, 628, 1905.

52. Solubility of calcium carbonate and lime in fused sodium carbonate and in fused sodium sulphate: Its importance in the manufacture of glass.

R. C. RAY.

It is well known that in the manufacture of glass the use of calcium carbonate in place of calcium oxide is more satisfactory, although one would expect a contrary result, as the chemical reaction is essentially between calcium oxide and silica in both the cases. It has been found experimentally that calcium carbonate dissolved to a greater extent in fused sodium carbonate than lime. Similar results have also been obtained in the case of fused sodium sulphate, which in certain cases used in place of sodium carbonate for the manufacture of glass. This increased solubility, no doubt, accounts for the better results obtained when calcium carbonate is substituted for calcium oxide.

53. Solubility of chromium trioxide in sulphuric acid.

H. R. IYENGER, Bangalore.

Solubility of chromium trioxide in sulphuric acid solutions of different strengths has been accurately measured as 30°C. A minimum in the curve is observed for sulphuric acid of about 75% strength. A tentative explanation is given. Electrical conductivities of the different solutions are being measured.

54. Note on the use of acid potassium sulphate in the manufacture of potassium bichromate.

R. L. DATTA.

In the manufacture of bichromate of potash from bichromate of soda by the addition of acid potassium sulphate cake as a source of potash, it has been found that during the salting out of sodium sulphate in the process of concentration, a considerable portion of potassium sulphate, about 33% is thrown out of the solution in admixture with sodium sulphate making the use of the acid potassium sulphate impracticable. It has been found that if some sodium chloride usually half the equivalent quantity of potash contained in the solution be added before the commencement of the salting, none of the potassium sulphate comes out along with sodium sulphate. The mother-liquor after crystallisation of the potassium bichromate will contain all the sodium chloride and can be mixed with fresh charges for evaporation. It has been found necessary to add very small quantities in fresh charges to make up for the mechanical losses of chlorine during the salting process.

55. The reaction between bismuth trisulphide and hydrochloric acid.

S. RAMACHANDRAN.

A qualitative study of the reaction between bismuth trisulphide and hydrochloric acid was undertaken by me sometime back and the results of a series of experiments are given below.

1. Although it is mentioned in some text-books that bismuth trisulphide dissolves in "boiling concentrated hydrochloric acid," it was observed that it is dissolved easily in the cold concentrated acid of sp. gr. 1.16 with distinct liberation of sulphuretted hydrogen and that it is completely soluble in the boiling acid of concentration 1.5Aq. Hence it was not possible to precipitate bismuth as the sulphide from a solution of its salt in excess of concentrated hydrochloric acid.

2. Hydrochloric acid of all concentrations (only concentrations up to 1.16Aq. were used) react with bismuth trisulphide liberating hydrogen sulphide but the evolution of the gas begins at increasing temperatures with increasing dilution of the acid.

3. By digesting the well-powdered sulphide of bismuth with hydrochloric acid of different concentrations for half an hour each at laboratory temperature, filtering off the unacted substance, and passing sulphuretted hydrogen through the clear filtrates, it was definitely shown that interaction does proceed between the two substances—irrespective of the dilution of the acid even at ordinary temperatures.

Experiments of a quantitative nature are in contemplation.

56. A new method of preparing dithiophosphates and some new dithiophosphates.

P. NEOGI and MANINDRA CHANDRA GHOSE.

No method at present exists for the preparation of mono-, di-, tri thiophosphates singly. Kubeirsckky obtained a mixture of the three kinds of thiophosphates by the action of caustic soda and phosphorus pentasulphide. After repeated attempts we have found that pure dithiophosphates were obtained by the action of powdered phosphorus pentasulphide on magnesium oxide suspended in ice-cold water. A brisk action took place both the phosphorus pentasulphide and magnesium oxide going into solution, whilst sulphuretted hydrogen was evolved. The following reaction took place, $3\text{MgO} + \text{P}_2\text{S}_5 + \text{H}_2\text{O} = \text{Mg}(\text{PS}_2\text{O}_2)_2 + \text{H}_2\text{S}$. The magnesium salt was precipitated with excess of alcohol and dried in a

vacuum desiccator in an ice-chest containing ice and salt. The alkali salts were prepared by the action of the corresponding caustic alkali on the magnesium salt when magnesium hydroxide was precipitated and the alkali salt went into solution from which these were precipitated with excess of alcohol. Insoluble dithiophosphates were prepared by double decomposition of the sodium salt with soluble salts of different metals. By this method we were able to prepare dithiophosphates of sodium, potassium, ammonium, calcium, barium, magnesium, lead, thallium and zinc. Of these the potassium, calcium, magnesium, lead, thallium and zinc compounds were hitherto unknown. Other dithiophosphates such as those of manganese, mercuric mercury, thorium and lanthanum were also obtained but they decomposed during drying. What were presumably dithiophosphates of bismuth, copper, mercuric mercury, nickel, cobalt, cadmium, silver and ferrous iron were found to be still more unstable and decomposed within a few seconds of their precipitation.

57. Further action of magnesium amalgam on nitrates and its action on nitrous acid and salts of the oxyacids of sulphur and the halogens.

P. NEOGI and RAMESH CHANDRA BHATTACHARJEE.

The action of magnesium amalgam on metallic nitrates has been studied by Neogi and Nandi (*Journal Chem. Soc. Lond.*, 1928) when it has been shown that besides hydroxylamine and ammonia, hyponitrites of the respective metals were formed. This method of preparing hyponitrites has been extended to uranium, beryllium and cerium which yielded unstable hyponitrites. Nitrous acid yields pure magnesium nitrite which has hitherto been prepared by double decomposition. Chlorates and perchlorates are unaffected. Bromates are reduced to bromides and iodates to iodides. Periodates are reduced first to iodates and then to iodides. Sulphates are unaffected. Sulphites and bisulphites were not reduced to sulphides as was expected. Sodium thiosulphate was reduced to a mixture of sulphide and sulphite but sodium dithionate was unaffected. Potassium persulphate was vigorously acted upon by the amalgam when a mixture of magnesium and potassium sulphates was formed whilst a precipitate of yellow oxide of mercury was obtained.

58. Thallium diuranate and an experimental review of the wet methods of preparing diuranates.

P. NEOGI and RAMESH CHANDRA BHATTACHARJEE.

Two wet methods of preparing diuranates are known—(1) by adding alkalis to the solution of an uranyl compound by which method only the alkali diuranates were obtained, (2) by adding ammonia to a solution of uranyl nitrate or chloride mixed with the corresponding salt of the metal of which the diuranate is required. A third wet method of preparing diuranates of heavy metals is described *viz.*, first precipitating the hydroxide of the metal with caustic alkalis and heating the washed hydroxide with uranyl nitrate. The last method succeeded in the case of the silver salt as already known. It was also found to be applicable to the lead and thallium compounds, but the yellow precipitates obtained in the case of copper, zinc, nickel, cobalt, magnesium and beryllium hydroxides consisted mostly of uranyl hydroxides and not diuranates. Thallium diuranate, a new compound, was also prepared by the second method mentioned above but the latter was found inapplicable to the case of lead, silver, copper, manganese, nickel and cobalt salts. A wet method of preparing diuranates universally applicable to all metals has yet to be discovered.

59. A new gravimetric method for the estimation of lead and separation from other metals.

P. N. DAS-GUPTA, G. C. RAY and K. M. Sil.

Lead has been estimated gravimetrically as $Pb_3O_4 \cdot 3H_2O$ in its soluble salts by hydrogen peroxide and ammonia, accordingly lead is separated and estimated when present with copper, cadmium, etc., as nitrates. In presence of ammonium nitrate or acetate and within certain limit of their concentration lead is quantitatively precipitated by hydrogen peroxide and ammonia. This is utilised in separating and estimating lead from zinc, nickel, calcium, barium, strontium and magnesium.

60. Use of phenolic hydroxy acids in the detection and estimation of metals.

P. N. DAS-GUPTA.

The action of phenolic hydroxy acids such as tannic or gallic followed by the addition of sodium acetate to neutral or faintly acidic solutions of metallic salts has been studied with the results that some give white precipitates, some give coloured solutions or precipitates and some give no precipitates at all even when a solution of a salt such as sodium or ammonium chloride is added afterwards. Thus the separation of chromium from aluminium, beryllium (which are quantitatively precipitated), etc., is possible. By gallic acid and sodium acetate in the cold, aluminium is separated from beryllium in their neutral solution and in the filtrate beryllium is precipitated on boiling. The separations are being carried out on the quantitative basis.

In the case of uranium, titanium, vanadium, molybdenum and tungsten, coloured solutions or precipitates are obtained, which serve to detect minute traces of them. With certain modifications only coloured solutions are obtained, which in the case of uranium has been utilised for its colorimetric estimation.* For the rest the colorimetric estimation is in progress. Uranium, titanium, and vanadium with gallic acid and sodium acetate give brown, yellow and green colourations respectively. They are detected in presence of one another from the following observations:—the colour due to uranium vanishes on adding dilute mineral and acetic acids, that due to titanium vanishes by adding dilute mineral acids; whereas the colour due to vanadium changes to greenish yellow by dilute acids, but in the presence of uranium with dilute sulphuric acid, the mixed colour changes to reddish brown instead of greenish yellow.

61. Studies on the dependence of optical rotatory power on chemical constitution. Part VIII. Stereoisomeric *p*-phenylenebisimino-camphors, *p*-phenylenebisamino-camphors and their derivatives.

B. K. SINGH and B. BHADURI.

Up till the year 1920, Forster's *p*-phenylenebisimino-*d*-camphor (*J.C.S.*, 1909, 95, 942) was the classical instance among carbon compounds, of a substance endowed with the highest rotatory power. The rotation constants of this compound were subsequently found to be exceeded by two substances prepared by one of us, namely 1:4-naphthylene-bisimino-*d*-camphor (*J.C.S.*, 1920, 117, 1599) and *pp*-bisimino-*d*-camphordiphenylamine (*J.C.S.*, 1921, 119, 1975). We have now studied the three stereoisomerides (*d,l*-, *dl*-) of *p*-phenylenebisimino-camphor and have determined the rotatory powers of the optically active isomers for three wave-lengths (Mg_{green} , Hg_{yellow} , and Na_D) in six different solvents at 35°C for equal

concentrations (about 0.07-0.08 per cent.). The rotatory powers of d- and l-isomerides are identical (within experimental error) and exhibit the following order of decreasing rotatory power in different solvents: Benzene > Pyridine > Chloroform > Acetone > Ethyl alcohol > Methyl alcohol.

Forster (*loc. cit.*, p. 955) stated that "attempts to reduce this compound (*p*-phenylenebisimino-d-camphor) have failed." We have found that this failure was due to the rapid oxidation of the reduced compound. We have succeeded in reducing this compound as well as its l- and dl-isomerides and isolating the bisamino-compounds as hydrochlorides. The free bases are precipitated by the addition of water to the alcoholic solution of the hydrochlorides and melt at 204° (d- and l-) and at 215°-18° with decomposition (dl-). We have also determined the rotatory powers of the optically active isomers of this compound for three wave-lengths (Hg_{green} , Hg_{yellow} , and Na_D) in six different solvents at 35° for equal concentrations (about 0.2 per cent. for ethyl and methyl alcohols and about 0.4 per cent. for other solvents). The rotatory power of d- & l-isomerides are identical and exhibit the following order of decreasing rotatory power in different solvents: Chloroform > Benzene > Acetone > Ethyl alcohol > Methyl alcohol > Pyridine.

The three stereoisomeric bases yielded mono-acetyl derivatives. The rotatory power of the acetyl derivatives are dextro and laevo for the d- and l-isomerides respectively, in chloroform solution, but the sign of rotation is opposite in pyridine solution for Hg_{green} , Hg_{yellow} , and Na_D and the same for Hg_{violet} .

Further work with analogous reduced compounds of this series is in progress.

62. The synthesis of cochenillic acid.

A. N. MELDRUM and K. S. VAIDYANATHAN.

The authors have synthesised cochenillic acid, starting with sym-hydroxytoluic acid. (a) The methyl ether of the acid was condensed with chloral, as in the synthesis of β - and γ -coccinic acids (*J. C. S. T.*, 1911, 99, 1712). (b) The condensation product was reduced so that the group $-\text{CH}(\text{OH})-\text{CCl}_3$ became $-\text{CH}_2-\text{CHCl}_2$. (c) Treatment of the product with sulphuric acid led to hydrolysis and oxidation, so that $\text{CH}_2-\text{CHCl}_2$ became CH_2-COOH . The result is a substance containing a $-\text{CH}_2-\text{CO}_2\text{H}$ group in the *ortho* position to the carboxyl group of the original acid. The process was then continued as before: (a) condensation with chloral; (b) reduction; and (c) hydrolysis and oxidation. The resulting substance contains two $-\text{CH}_2-\text{COOH}$ groups in *ortho* positions to the carboxyl group of the original acid. This substance on oxidation with alkaline potassium permanganate yielded cochenillic acid.

63. On some derivatives of 4-phenylcoumarin.

P. C. MITTER and P. K. PAL.

In connection with some synthetic experiments it was necessary to prepare and study the properties of some hydroxylated 4-phenyl coumarins.

Ethyl β :2:4-dimethoxyphenyl- β -hydroxy cinnamate (m. p. 79°) was prepared by condensing 2:4-dimethoxybenzophenone with bromacetic ester in presence of zinc. On distilling in vacuum it lost water and yielded ethyl β :2:4-dimethoxyphenyl cinnamate (b. p. 228-232/9 mm.) which on hydrolysis with methyl alcoholic potash gave β :2:4-dimethoxyphenyl cinnamic acid (m. p. 169°). The acid was converted, by the action of acetyl chloride and glacial acetic acid, into 7-methoxy-4-phenylcoumarin (m. p. 110°). The cinnamic acid can be reduced by

sodium amalgam to the corresponding dihydrocinnamic acid, m. p. 129° (ethyl ester, m. p. 53°–54°).

64. Interaction of chlorosulphuric acid on substances containing the reactive methylene ($-\text{CO}-\text{CH}_2-\text{CO}-$) group.

K. G. NAIK and C. H. SHAH.

This work was undertaken to study the reactivity of the hydrogens of a methylene group with the help of chlorosulphuric acid. The following compounds were investigated:—

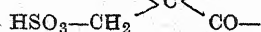
(1) Malonanilide (2) Malon-dibenzylamide (3) Malon-di-p-toluidide (4) Malon-di-o-toluidide (5) Malon-di-m-toluidide (6) Malon di- α -naphthylamide (7) Malon-di- β -naphthylamide (8) Malon-mono-p-tolylamide (9) Malon-di-propylamide (10) Malon-di (1 : 3 : 4)-xylidide (11) Methyl malonanilide (12) Methyl malon-di-p-toluidide (13) Methyl malon di-m-toluidide (14) Methyl-malon-di-o-toluidide (15) Methyl malon di- α -naphthylamide (16) Methyl malon-di- β -naphthylamide (17) Methyl malon-di (1 : 3 : 4)-xylidide. Of these (10), (15), (16) and (17) were prepared for the first time by a method similar to that of Waiteley (*J. C. S. T.*, 1903, 83, 24) for the preparation of substituted malonamides.

Compounds (1) to (8) and (10) gave di-sulpho-derivatives of the

general formula $(\text{HSO}_3)_2 \cdot \text{C} \begin{matrix} \text{CO—} \\ \diagup \quad \diagdown \\ \text{CO—} \end{matrix}$, whereas (9) gave a monosulpho-

derivative $(\text{HSO}_3) \cdot \text{CH} \begin{matrix} \text{CO—} \\ \diagup \quad \diagdown \\ \text{CO—} \end{matrix}$

In the case of compounds (11) to (17) disulpho-derivatives of the general formula $\text{HSO}_3 \cdot \text{C} \begin{matrix} \text{CO—} \\ \diagup \quad \diagdown \\ \text{CO—} \end{matrix}$ were obtained.



Salts of these derivatives were prepared in which the hydrogen of the sulphonic group was replaced by K, Na, NH_4 or Ba.

Nitration of the sulpho-derivatives was also carried out when it was found that the sulphonic group was replaced by the nitro groups.

65. Interaction of sulphuryl chloride with organic compounds containing the reactive methylene (CH_2) group. Part II.

K. G. NAIK and H. R. DESAI.

The work described is a continuation of the work already published (Naik and Shah, *J. I. C. S.*, 1927, 4, 11). During this work one of the negative groups ($\text{CN}-$) was common to all the compounds investigated, and the negativity of the other group was slowly altered. (1) Cyan-acet-p-toluidide, (2) cyan-acet-o-toluidide, (3) cyanacet-m-toluidide, (4) cyanacet- α -naphthylamide, (5) cyanacet- β -naphthylamide, (6) cyanacet-(1-5-4)-xylidide, (7) cyanacet ethylamide, (8) cyanacet propylamide and (9) cyanacet methyl anilide were made to interact with sulphuryl chloride in dry benzene solution. Of these (8) and (9) were prepared for the first time; (8) was prepared by heating the cyanacetic ester with the amine in molecular proportion; while for (9) a method similar to that of Freund (*Ber.*, 17, 137) for the preparation of malon-di-methylanilide was adopted.

In the case of compounds (1), (2), (3), (7), (8) and (9) only one hydrogen of the methylene group was replaced by chlorine whereas in (3), (4) and (6) both the hydrogens were replaced.

These results show that there is some difference in the two hydrogens of such a methylene ($\text{CN}-\text{CH}_2-\text{CO}-$) group, as was suggested by Naik (*J. C. S. T.*, 1921, 119, 379; 1921, 119, 1231).

66. Interaction of selenium tetrachloride with organic compounds containing the reactive methylene group.

K. G. NAIK and R. K. TRIVEDI.

The reactivity of the hydrogen atoms of a methylene group ($-\text{CO}-\text{CH}_2-\text{CO}-$) was studied with the help of selenium tetrachloride. The following substances were examined:—

(1) Malonanilide (2) Malon-di-p-toluidide (3) Malon-di- α -toluidide (4) Malon-di- β -naphthylamide (5) Methyl-malonanilide (6) Methyl-malon-di-p-toluidide (7) Methyl-malon-di-m-toluidide (8) Methyl-malon-di- β -naphthylamide (9) Malon-di-benzylamide (10) Malon-dipropylamide (11) Malon-di-heptylamide (12) Malon-di-(1:3:4) xylidide (13) Malon-di-(1:4:5) xylidide (14) Malon-di- α -naphthylamide (15) Malonamide (16) Malon-mono-phenylamide (17) Malon-mono-p-tolylamide (18) Malon-p-tolylamide (19) Malonic ester, in the presence of dry ether at ordinary temp.

Of these compounds (1) to (4) gave selenides of the general type $-\text{CO}-\text{C}(\text{Se})-\text{CO}-$. While in the case of (5) to (8) in which a substituted methylene group ($-\text{CO}-\text{C}(\text{CH}_3)\text{H.CO}-$) was present, compounds

of the general type
$$\begin{array}{c} -\text{CO} \\ \diagup \\ \text{C}(\text{CH}_3)-\text{Se}-(\text{CH}_3) \\ \diagdown \\ -\text{CO} \end{array} \begin{array}{c} \text{CO} \\ \diagdown \\ \text{C} \\ \diagup \\ \text{CO} \end{array}$$
 were formed.

Compounds (9) to (13) reacted to give chloro-compounds of the type $-\text{CO}-\text{CCl}_2-\text{CO}-$ whereas compounds (14) to (17) did not react at all. Compounds (18) and (19) formed resinous products.

The results go to show that selenium tetrachloride acts according to the equation,

$2\text{SeCl}_4 \rightarrow \text{Se}_2\text{Cl}_2 + 3\text{Cl}_2$ and further (i) $>\text{CH}_2 + \text{Se}_2\text{Cl}_2 \rightarrow >\text{C}:\text{Se}$ and (ii) $>\text{CH}_2 + \text{Cl}_2 \rightarrow >\text{CCl}_2$, it at first decomposing into selenious chloride and free chlorine.

When the bromination of the compounds was carried out it was found that the Se was replaced by bromine. Nitration of these compounds gave resinous products.

It was also found that the reactivity of the hydrogens of a methylene group is influenced in much the same way by the adjacent groupings as was found by Naik and his collaborators.

67. Isomeric iminothiobiazolones and iminothiol-thiobiazoles.

P. C. GUHA and S. L. JANNIAH.

Different melting points have been attributed to Freund's dithiourazole (proved later on to be iminothiolthiobiazole) by different workers including one of us (P. C. G.). It has now been obtained in three different forms under different conditions of experiments: m.p. 224°, 235° and 244°; and their interconversion has also been found to be possible. A lower melting variety (203°) of their mother substance $\text{H}_2\text{N}.\text{CS}.\text{NH}.\text{NH}.\text{CS}.\text{NH}_2$ (m.p. 223°) has been isolated. 2-R-imino-1:3:4-thiobiazole-5-ones and their mother substances *viz.*, $\text{R}.\text{NH}.\text{CS}.\text{NH}.\text{NH}.\text{CO}.\text{NH}_2$ have also been obtained in different isomeric forms.

68. Constituents of *Ipoemea turpethum*.

A. JANAKI RAM.

Ipoemea turpethum (Sans. trivrit, triputa) is a valuable purgative drug of the Ayurvedic Pharmacopoeia. Spargatis, in 1893 (Annalen, 139, 41), and Votocek and Kastner in 1907 (J. C. S. A, i, 330) attempted the isolation and identification of various constituents of the drug with partial success. The present investigation was undertaken with a view to effect a complete chemical analysis of the drug. After a small scale preliminary extraction with various solvents successively, of the rhizome powder, the alcoholic extract of a large quantity was obtained—as a dark brown resin. The steam distillate of the resin was found to contain isoamyl alcohol, a trace of phenol, and valeric acid. The nonvolatile portion gave cerotic and stearic acids, and a phytosterol, m. p. 290°, probably ipuranol. Further work is in progress.

69. Urethane, acetamide, benzamide, etc., as reagents for the synthesis of aminoacids.

P. C. GUHA and T. N. GHOSH.

Ethyl cinnamate in ethereal solution reacts with the Na-derivatives of urethane, etc., to yield a compound like $\text{PhCH}(\text{NH}.\text{COOEt})\text{CH}_2.\text{COOEt}$, from which the insoluble copper derivative is readily obtained which in its turn give $\text{PhCH}(\text{NHCOOEt})\text{CH}_2.\text{COOEt}$ on treatment with dilute acids. Similar compounds have been obtained from o-, m-, and p-nitrocinnamic esters, citraconic esters and furmaric esters on the one hand and acetamide, benzamide, etc., on the other. Hydrolysis of the ester groups and elimination of CO_2 is being studied now.

70. Monosubstituted carbohydrazides and the ring closure of some of their typical derivatives.

P. C. GUHA and ABDUL HYE.

Monosubstituted carbohydrazides are not known. Phenyl and o-tolylcarbohydrazides have now been prepared by heating the alcoholic solution of phenyl and tolyl-carbazinic esters in sealed tubes at 120-125° for 12 hours. They yield monophenylcarbohydrazones with aldehydes and ketones and azoimides with nitrous acid. PhNHNHCONHNHCOSSK and PhNHNHCONHNHCOOEt obtained by the action of EtO.COSSK and $\text{Cl}.\text{COOEt}$ respectively upon phenylcarbohydrazide yield 2-phenylhydrazino-5-thiol-1: 3: 4-thiodiazole and 2-phenylhydrazino-5-ethoxy-1: 3: 4-oxdiazole on ring closure. With thiocarbimides and isocyanates compound of the type of PhNHNHCONHNHCSNHR and PhNHNHCONHNHCONHR are obtained of which the former ones (carbothio-phenylamides) yield 1-N-R-monothiourazoles and 2-keto-5-R-iminothiobiazoles by the ring closing action of HCl , NaOH , FeCl_3 and acetic anhydride.

71. Condensation of dimethyldihydroresorcinol with aromatic aldehydes. Part I. Pyranol, pyran and triphenylmethane compounds.

G. C. CHAKRAVARTI, H. CHATTOPADHYAYA and P. C. GHOSH.

Dimethyldihydroresorcinol has been condensed with various aromatic aldehydes using alcoholic potash and HCl gas. In presence of potash triphenylmethane derivatives are formed, the latter with acetic anhydride are converted into the corresponding phenylxanthenes. Compounds have been obtained with anisaldehyde, vanillin, piperonal, p- and

m-nitro- and 4-oxy- and 3:4-dihydroxybenzaldehydes, and cinamaldehydes. Free and substituted salicylaldehydes however yield pyran derivatives.

With HCl gas the first named aldehydes give benzylidene compounds while salicylaldehyde and its derivatives form coloured pyranol anhydrochlorides. It is suggested that the colour of the latter class of compounds is due to the shifting of a pair of double bonds to the benzene nucleus resulting in the production of quinonoid derivatives.

Several derivatives of the different classes of compounds have also been studied.

72. Condensation of dimethyl-dihydro-resorcinol with aromatic aldehydes: Part II. Acridine and benzoquinoline derivatives.

B. H. IYER and G. C. CHAKRAVARTI, Bangalore.

When dimethyl-dihydro-resorcinol is condensed with o-amino-benzaldehyde in presence of alcoholic potash, one molecule of each react together forming 2-dimethyl-1:3-dihydro-4-keto-acridine, m.p. 117°C. (I) which compound gives the following derivatives *viz.*, (a) platinichloride (b) methiodide, m. p. 224–225°C (c) two phenylhydrazones one melting at 128–130°C and the other at 191–193°C, according to the conditions of experiment. The product (I) on oxidation with concentrated nitric acid gives acridinic acid.

When dimethyl-dihydroresorcinol is condensed with o-acetaminobenzaldehyde in presence of alcoholic potash the same acridine derivative (I) is obtained; but in the absence of potash 2-acet-amino-benzylidene-dimethyl-dihydro-resorcin, m.p. 153–154°C is formed. The product on hydrolysis with alcoholic potash goes back to the acridine derivative (I).

On carrying out the above condensation in presence of zinc chloride, both in alcoholic solution and in dry conditions, 2-dimethyl-4-oxy-N-acetyl-benzoquinoline melting at 203–204°C is obtained. This compound on hydrolysis with aqueous-alcoholic potash gives the acridine derivative (I); but with absolute alcoholic potash, gives a product m.p. 245–250°C (d).

When dimethyl-dihydro-resorcinol is condensed with o-nitro-benzaldehyde, 2-nitrobenzal-dimethyldihydroresorcin, m.p. 195°C is formed. Experiments are in progress to reduce it to a pyridine derivative.

Condensation of dimethyl-dihydro-resorcinol with 5-nitro-2-acetaminobenzaldehyde has also been studied under all the above conditions.

73. Colour of complex diazoles—Part IV.

M. V. BETRABET and G. C. CHAKRAVARTI, Bangalore.

A detailed investigation of the absorption spectra of some typical coloured and colourless compounds containing fused pyrroleiminazole or pyridine-iminazole ring systems has been carried out. All of them give a characteristic similar absorption band in the ultraviolet region between $\frac{1}{\lambda}=3000$ and $\frac{1}{\lambda}=3900$; while the coloured ones give an additional characteristic band near the blue end in the visible or just in the ultra-violet region. The experimental results support the view put forward by one of us (Chakravarti, Science Congress Abstracts, 1928—Sec. III—28) that the colour depends upon the existence of two pairs of double bonds in the pyrrole or pyridine rings (for which a conventional term "Double Ortho-Quinoid Structure" was adopted), combined with the auxochromic character of the weakly basic iminazole skeletons. Because in diazoles containing reduced pyrrole or pyridine rings one of the prominent absorption bands entirely disappears. On the other hand

the character of the absorption bands remains unaltered if the pyrrole-iminazole or pyridine-iminazole skeletons are not disturbed, however different may be the nature of the associated groups.

Other diazoles also have been prepared from hexahydrophthalic acid and aromatic diamines in which two of the double bonds in pyrrole ring are reduced, yielding colourless compounds. The absorption curves are also different from those of the unreduced diazoles.

74. Action of sulphur-monochloride on mercaptans—Part II: Formation of organic tri- and penta-sulphides—behaviour with substituted thiosemicarbazides.

P. P. PATEL and G. C. CHAKRAVARTI, Bangalore.

In continuation of the observations made by one of us, (Chakravarti, *J.C.S.*, 1923, 122, 964) it is found that when the condition of the reaction is altered, trisulphides and *probably* pentasulphides are formed instead of the tetrasulphides. Tri- and penta-sulphides from the following aromatic mercaptans have been studied, *viz.*, phenyl, tolyl, brom- and iodophenyl, benzyl and β -naphthyl mercaptans. The trisulphides are mostly well defined crystalline substances, whereas the pentasulphides are thick, non-volatile, uncrystallisable, oily and hence difficult to purify. The latter give colour reactions with piperidine. With ethyl, propyl and butyl mercaptans the corresponding aliphatic trisulphides have been isolated. These are mobile oils, volatile with steam.

The action of sulphur monochloride has been tried on potential mercaptans, such as mono and disubstituted thiosemicarbazides, 4-phenyl-, 4-p-tolyl- and 4-o-tolyl-thiosemicarbazides give the corresponding 2:5-disubstituted, 2:3:4:5-tetrahydro-1:3:4-thiodiazoles along with small quantities of 1:6-disubstituted hydrazinedithio-dicarbonamides.

75. The preparation and physical properties of mono-glycerides.

R. S. REWADIKAR.

The α -monoglycerides of acids with an even number of carbon atoms from C_3 to C_{18} have been prepared in a pure state by Fischer's method and the melting points, refractive indices, densities, viscosities and surface tensions determined.

Glycerolysis experiments have been tried successfully using sodium methylate and hydrogen chloride as catalysts.

Allyl stearate has been oxidised to monostearin and direct evidence thus obtained for the α -structure of the compounds under investigation.

α -Monocaprin and caprylin and their diphenyl urethanes and dinitrobenzoyl derivatives, allyl esters of stearic and lauric acids and their dibromides have been synthesised.

76. Studies in the synthesis of higher fatty acids with normal as well as branched chains. Part I. The action of magnesium and zinc alkylhaloid compounds on derivatives of dibasic acids.

P. RAMASWAMI AYYAR and V. A. PATWARDHAN.

The action of a Grignard reagent like magnesium *iso*amyl bromide on the ester of a dibasic acid like diethyl succinate may by proper regulation of the proportions of the reacting substances, be expected to yield one or

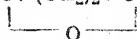
more of the following substances according to the vigour of the reaction:—

- (a) $C_5H_{11} \cdot CO \cdot (CH_2)_2 \cdot COOH$;
 (b) $(C_5H_{11})_2 \cdot C \cdot OH \cdot (CH_2)_2 \cdot COOH$; or its lactone;
 (c) $C_5H_{11})_2 \cdot C \cdot OH \cdot (CH_2)_2 \cdot C \cdot OH \cdot (C_5H_{11})_2$.

It is shown that by interacting equimolecular proportions, a fair yield of the lactone of (b) (b. p. 150° – 151° C/4 mm.) is obtained. The product is the same, even if the ester is replaced by the anhydride or the half-ester acid chloride of succinic acid.

Using the same method, the following additional hydroxy acids have been prepared:—

- (2) $(C_2H_5)_2 \cdot C \cdot (CH_2)_2 \cdot CO$; (b. p. 96° – 97° C/3 mm.)



from magnesium ethyl iodide and half ester acid chloride of succinic acid.

(3) $(CH_3)_2 \cdot C \cdot OH \cdot (CH_2)_6 \cdot COOH$; (m. p. 48° – 49° C) from magnesium methyl iodide and ethyl suberate.

(4) $(CH_3)_2 \cdot C \cdot OH \cdot (CH_2)_8 \cdot COOH$; (m. p. 62° C) from magnesium methyl iodide and methyl sebacate.

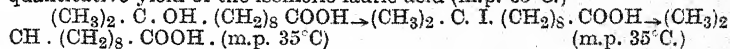
In (3) and (4), the corresponding glycols are obtained in good quantity.

In a similar way, the action of zinc-*iso*-butyl iodide, on the half-ester acid chloride of succinic acid is shown to give the keto-acid, $C_4H_9 \cdot CO \cdot (CH_2)_2 \cdot COOH$, m.p. 40° , b. p. 146° – 147° C/4.5 mm. in good yield.

77. Studies in the synthesis of higher fatty acids with normal as well as branched chains. Part II. Preparation of 10-methyl undecic acid (an isomer of lauric acid), from 10-methyl-10-hydroxyundecic acid.

P. RAMASWAMI AYYAR and V. A. PATWARDHAN.

The hydroxy acid on boiling with strong hydriodic acid in presence of red phosphorus, yields a product contaminated with an iodo-fatty acid. The latter on treatment with zinc dust and glacial acetic acid gives a quantitative yield of the isomeric lauric acid (m.p. 35° C.)



The reduction of the other keto and hydroxy acids mentioned in Part I is in progress.

78. The use of thionyl bromide in the preparation of organic acid bromides.

M. A. GOVINDA RAU and K. VENKATARAMAN.

The preparation of thionyl bromide by Mayes and Partington in 1926 has been repeated. Full experimental details are given. The thionyl bromide was obtained in 80% yield.

Malonyl bromide, prepared by Fleischer, Hittel and Wolff in 1920 by passing hydrogen bromide through malonyl chloride, has now been made by warming malonic acid with thionyl bromide.

The constitution of succinyl chloride being still in doubt, the action of thionyl bromide on succinic acid and on succinic anhydride is being studied with a view to preparation of succinyl bromide.

79. Synthetical experiments in the chromone group—Part II. A synthesis of 7 : 8 : 3' : 4'—tetrahydroxyflavone and of 5 : 7 : 3' : 4'—tetrahydroxyflavone (Luteolin).

SUBRAMANIAM and K. VENKATARAMAN.

The condensation of gallacetophenone with veratric anhydride and sodium veratrate and hydrolysis of the product gave 7 : 8-dihydroxy-3' : 4'-dimethoxyflavone. Demethylation yielded the corresponding tetrahydroxyflavone, interesting in its dyeing properties on account of the simultaneous presence of two hydroxyls ortho to each other and to the pyrone oxygen and of two ortho hydroxyls in the 2-phenyl ring. For comparison with this flavone, 5 : 7 : 3' : 4'-tetrahydroxyflavone (luteolin) is being prepared. This substance, the yellow pigment of weld (*Reseda luteola*), has previously been synthesised by Kostanecki, Rozycki and Tambor: it is now being made by the general method of Allan and Robinson. Fusion of a mixture of phloracetophenone, veratric anhydride and sodium veratrate leads to 5 : 7-dihydroxy-3' : 4'-dimethoxyflavone and subsequent demethylation would yield luteolin.

In the methylation of vanillin to veratraldehyde the simplest method, methylation in aqueous alkaline solution by means of methyl sulphate, gave the best yield. The anhydride of veratric acid was obtained by boiling the acid with acetic anhydride during 24 hours. Allan and Robinson have prepared veratric anhydride by treatment of the acid in pyridine and benzene with phosgene in benzene.

80. Synthetical experiments in the chromone group—Part III. A synthesis of ω -methoxygallacetophenone and of 3 : 7 : 8-trihydroxy-2-methylchromone.

SUBRAMANIAM and K. VENKATARAMAN.

In order to synthesise chromonols with hydroxyls in the 7 : 8-positions it is necessary to use ω -methoxygallacetophenone as starting material. No reference to this substance is found in the literature and it has now been made by the interaction of pyrogallol with methoxyacetic acid and zinc chloride. The isolation of methoxyacetic acid from the suspension of its sodium salt in methyl alcohol (obtained by the double decomposition of chloroacetic acid and sodium methoxide) is best carried out by taking the whole to dryness, powdering the mass and shaking it with anhydrous ether saturated with hydrogen chloride. The new ketone has been characterised by its *p*-nitrophenylhydrazone and semicarbazone.

On treating ω -chlorogallacetophenone with sodium methoxide both ω -methoxygallacetophenone and 6 : 7-dihydroxyketocoumaran are formed, their relative proportion depending apparently on the conditions of the reaction.

The acetylation of ω -methoxygallacetophenone by means of boiling acetic anhydride and fused sodium acetate, followed by alkaline hydrolysis and acidification, gave 7 : 8-dihydroxy-3-methoxy-2-methylchromone. Treatment with hydriodic acid then led to 3 : 7 : 8-trihydroxy-2-methylchromone. The reactions and dyeing properties of this substance are described.

81. A new synthesis of dicinnamoylmethane.

K. VENKATARAMAN.

Langlois in 1919 has obtained benzylidene acetone by condensing acetyl chloride with styrene in presence of stannic chloride, and Norris and Couch in 1920 have carried out a synthesis of vinyl phenyl ketone by passing ethylene through a mixture of benzoyl chloride and aluminium

chloride. A similar Friedel-Crafts reaction between malonyl chloride and styrene offers an attractive synthesis of dicinnamoylmethane. The process has actually been found feasible, but the yields have been poor. It is probable that malonyl bromide, which has been shown by Fleischer, Hittel and Wolff in 1920 to condense with acenaphthene much more readily and smoothly than the chloride to give an indandione, will be likewise advantageous in the present instance. The work, including a synthesis of curcumin itself on the same lines, is in progress.

Both dicinnamoylmethane and curcumin have been previously synthesised by Lampe and his pupils by a series of reactions starting with acetoacetic ester.

82. Substitution in resorcinol derivatives. Part V. Bromination.

M. SESA IYENGAR and H. SUBBA JOIS, Bangalore.

It has been shown in a previous paper that when 2-hydroxy-4-methoxy benzaldehyde as well as its methyl and ethyl ethers are brominated in acetic acid medium the bromine atom always takes up position 5. (M. G. S. Rao, Iyengar, Indian Science Congress, 1926.)

With a view to find out definitely if the carboxy group will not have the same orienting effect on the newly entering bromine atom a few derivatives of β -resoreylic acid were brominated and the position taken up by bromine determined.

2: 4-Dimethoxybenzoic acid on bromination gives rise to 5-brom-2: 4-dimethoxy benzoic acid as the primary product (Indian Science Congress 1927) and 4: 6-dibrom resoreinol dimethyl ether as the secondary product (Kohn Loff, Monats. 45, 589, 1924).

2-Ethoxy-4-methoxy benzoic acid yields on similar treatment 5-brom-2-ethoxy-4-methoxy benzoic acid, m.p. 193°-194° as the primary product and 4: 6-dibrom-1-ethyl-3-methyl ether of resoreinol m.p. 97°-99° as the secondary product.

The paper deals with the experimental details and the arguments advanced to fix up the constitution of the new compounds obtained.

83. Substitution in resorcinol derivatives. Part VI.

M. SESA IYENGAR and H. SUBBA JOIS, Bangalore.

It was noticed that during the bromination of 5-nitro-2-hydroxy-4-methoxy-benzaldehyde, there might be some molecular rearrangement taking place (M. G. S. Rao and Srikantia, Indian Science Congress, 1925).

With a view to find out if any such migration of groups is noticeable during the bromination of methyl and ethyl ethers of 5-nitro-2-hydroxy-4-methoxy benzaldehyde and the corresponding acids, attempts were made to prepare the dibrom derivatives from the compounds above mentioned. So far only the monobrom derivatives have been got and they may be regarded as possessing the following constitution:—

(1) 4-Nitro-6-brom-resoreinol dimethyl ether, m.p. 140°-141°C.

(2) 4-Nitro-6-brom-resoreinol-1-ethyl-3-methyl ether, m.p. 119°-121°C.

The paper deals with the experimental details and the arguments advanced for the constitution of the new compounds.

84. The preparation of the substituted butyrolactams.

S. S. G. SIRCAR.

An investigation has been made of the various possible methods of preparing the β -mono-, and $\beta\beta$ -di-substituted butyrolactams. Most of the

methods applicable for the preparation of the α - and β -amino acids were found unsuitable for the preparation of these new compounds; and after a number of unsuccessful attempts had been made to reduce the imides of the β -substituted succinic and glutaric acids, the application of the Hofmann's reaction to the glutarimides was hit upon as being suitable for the purpose. A number of these lactams have thus been prepared, the β -substituents being: H, H; Me, H; Et, H; Me, Me; Me; Et: Et, Et; *cyclo*Pentane, and *cyclo*Hexane. The properties of these compounds have been investigated in detail.

85. The stability of the carbon to carbon double bond in some styrene derivatives. The substituted benzal-malonic acids.

S. S. G. SIRCAR.

A number of substituted benzalmalonic acids have been prepared with a view to comparing the ease with which the extra-nuclear C:C bond is opened. The reagent used for this purpose being semicarbazide or phenylhydrazine, which liberates the malonic acid and combines with the aldehyde which are the products of fission of the bond. The benzal-malonic acids so far prepared have the following substituents in the nucleus: H; o-, m-, and p-nitro-; o-, m-, and p-hydroxy-; o-, m-, and p-methyl; the cinnamylidene, anisylidene, vanillylidene and phenylacetylidene malonic acids have been prepared as well.

The quantitative study of these compounds is in progress. It is proposed to extend the study to a number of other unsaturated systems.

86. On the migration of *para* bromine atom in phenols.

S. M. SANE and B. N. PRAMANICK.

It has been shown in a previous paper (Sane and Joshi, *Jour. Ind. Chem. Soc.*, 1928, 5, 299) that the dinitro-m-cresol, m.p. 74°C, described by Gibbs and Robertson (*J.C.S.*, 1924, 105, 1889), the dinitro-m-cresol m.p. 74°C described by Will (B. 1914, 47, 712), and the dinitro-m-cresol m.p. 65°C described by Borsche (B. 1917, 50, 1350) are all identical having the constitution 1-methyl-3-hydroxy-4: 6-dinitrobenzene and the m.p. 74°C. The 1-methyl-2-bromo-3-hydroxy-4: 6-dinitrobenzene which is obtained from the latter, has the m.p. 115°-116°C.

A dinitrobromo-m-cresol having the m.p. 110°C has been described by Walther and Demmelmeyer (*J.Pr.Ch.* 92, 122 and 123). They prepare this by nitrating p-bromo-m-cresol (OH 1 and CH₃3). On repeating the work of these authors a mono and a dinitrobromo-m-cresol were obtained, but the m.p. of the dinitro compound rose to 114°-115°C on recrystallisation. On examining more closely it was found that this dinitrobromo-m-cresol is identical with the 1-methyl-2-bromo-3-hydroxy 4: 6-dinitrobenzene described by us in the previous paper. Walther and Demmelmeyer's dinitrobromo-m-cresol yields a toluenesulphonyl ester having the m.p. 114°C and a bromochlorodinitrotoluene having the m.p. 84°C. These are also obtained from 1-methyl-2-bromo-3-hydroxy-4: 6-dinitrobenzene.

Walther and Demmelmeyer assign to their dinitrobromo-m-cresol the constitution 1-methyl-3-hydroxy-2: 4-dinitro-6-bromobenzene; but during nitration of the 4: bromo-m-cresol, the *para* bromine atom appears to have migrated to the *ortho* position and the constitution of the resulting dinitro compound is not what they suppose, but is 1-methyl 2-bromo-3-hydroxy-4: 6-dinitrobenzene. Several cases of such migration are known. (Robertson, 1908, 93, 793; Robertson and Briscoe, T., 1912, 101, 1961; Robertson and Gibbs, T., 1914, 8886).

87. Nitration of dihydroxy benzols.

K. HABIB HASAN, Hyderabad, Deccan.

Nitrogen peroxide in ether and petroleum-ether solution easily nitrates catechol and resorcinol, but a difficulty is met with in nitrating quinol. Their ethers can also be nitrated with ease. Other phenols are being studied.

88. Studies in geometrical inversion.

P. NEOGI and S. K. MITRA.

This paper might be divided into three sections :—

(1) The first section is a continuation and confirmation of the work by P. Neogi, Chatterjee and S. Neogi (*Journ. Ind. Chem. Soc.* 1928) in which it was shown that neither manganese dioxide nor sulphur dioxide produces inversion in maleic acid, but when sulphur dioxide is passed through maleic acid solution containing manganese dioxide in suspension inversion takes place rapidly, the yield of fumaric acid being much greater than that obtained by Skraup using a mixture of sulphuretted hydrogen and sulphur dioxide solution. This work has been extended to citraconic and some other stereo-isomeric acids and their esters with positive results excepting with acids of high molecular weights. Negative results were obtained with (1) the products of the reaction of manganese dioxide and sulphurous acid taken collectively, (2) manganous sulphate, (3) manganous dithionates other dithionates and free dithionic acid, (4) tetrathionates, (5) action of sulphur trioxide and water, (6) product of oxidation of sulphur dioxide in presence of manganous sulphate as a catalyst, (7) sulphuric acid of all medium strengths, (8) highly exothermic reactions like the action of water on phosphorous pentoxide. These results conclusively show that the inversion takes place *in the midst of the chemical reaction* itself between sulphur dioxide and manganese dioxide and that a chemical reaction itself can act catalytically just as a single catalytic substance would do. This is not however what is called an "induced reaction" which is quite different. We have called such reactions as "*resonance reactions*."

(2) The second section deals with the search after new substances which would cause geometrical inversion. It was found that mono and di-thiophosphates and sulphocyanides would produce geometrical inversion whilst thio-arsenates, thio-urea and seleno-sulphates, gave negative results.

(3) Lastly a theory of geometrical inversion has been developed under the name of "*rotadynamism*."

89. Molecular rearrangement during bromination.

M. SESA IYENGAR and K. SANTANAM, Bangalore.

It has been pointed out in a previous paper (M. G. S. Rao and Srikanthiah, Indian Science Congress, 1926) that during the bromination of 5-nitro-2-hydroxy-4-methoxy benzaldehyde a rearrangement of certain groups in the molecule is noticeable.

In the course of further experiments done with a view to determine which group or atom may have wandered, it was found that on treating a solution of 5-nitro-2-hydroxy-4-methoxy benzaldehyde in nitric acid (1.42) with bromine a product m.p. (104°-105°) was obtained which was found to be identical with that obtained by nitrating 5-bromo-2-hydroxy-4-methoxy benzaldehyde. This led to a systematic investigation of the products obtained by nitrating the above substance under different conditions. As a result of nitration the following three substances were obtained :—

1. 5-Bromo-3-nitro-2-hydroxy-4-methoxy benzaldehyde, m.p. 126°-127°
2. 4-Bromo-6-nitro-resorcinol-3-methyl ether, m.p. 116°-117°
3. A brom dinitro derivative, m.p. 104°-105°

The paper deals not only with the position taken up by the nitro groups in the compounds obtained but also with the further evidence—adduced to show the possibility and nature of molecular rearrangement during bromination.

90. Tetraphenylmethane derivatives.

R. N. SEN and S. K. BANERJEE, Calcutta.

Only a few tetraphenylmethane derivatives have been prepared up to date (Baeyer and Villiger, *Ber.*, 1902, 35, 3013-3033), (Ullmann and Munzhuber, *Ber.*, 1903, 36, 404-410) and they are either mono or di-substituted (T. 1901, 1209, 150) (*Annalen*, 1908, 363, 284-301) (J. Pr. chem. 1901, II, 82) (Boyd and Hardy, *Jour. Chem. Soc.* Mar, 1928; this paper was published when this work was in progress.)

In this paper a systematic study has been made of several tetrasubstituted tetraphenylmethane derivatives obtained by heating at 150°-170°C, rosaniline base (R) with aromatic hydroxy—, amino—, or substituted amino-compounds, in presence of sodium acetate. It is remarkable that these derivatives are excellent dyes in spite of the absence of any chromophores or the ordinary quinonoid configuration. This is explained by assuming that tetraphenylmethane itself is a colourless chromogen in which visible colour is developed by auxochromic substitutions in at least three nuclei.

Thus tetra-amino tetraphenylmethane (1) (R+aniline) dyes wool and silk bluish violet. Tetramethyl derivative of (1) bluer shade; dimethyl derivative (R+dimethyl aniline) slightly redder than (1); monoacetyl derivative (R+acetanilide) brownish grey; tetra-acetyl derivative very slightly coloured no dyeing property; tetra benzoyl derivative:—nearly colourless, no dyeing property.

Mono-hydroxy triamino-tetraphenylmethane (R+phenol):—violet dye, marked loss of affinity for the fibre; its mono-methyl-ether (R+anisole):—dyeing property restored, reddish violet dye. 2: 4-Dihydroxy triamino tetraphenylmethane (R+resorcinol) and 2: 3: 4-trihydroxy triamino tetraphenylmethane (R+pyrogallol) both produce different shades of violet, the latter bluer.

Triamino-p-hydroxytetraphenylmethane-m-carboxylic acid (R+salicylic acid), triamino-p-hydroxy tetraphenylmethane-o-carboxylic acid (R+m-hydroxy benzoic acid) triamino-o-hydroxy tetraphenylmethane m-carboxylic acid (R+p-hydroxy benzoic acid), triamono-p-hydroxy m-methyl tetraphenylmethane m-carboxylic acid (R+o-cresotinic acid) all produce different shades of bluish-violet; bluest with the last.

The corresponding hydroxy compounds obtained by diazotization give dye-shades varying from yellow to orange.

91. The reaction between acetylene and sulphur between the temperatures 290° and 390°.

C. T. BHATT, K. S. NARGUND, and D. D. Kanga.

The reaction products of acetylene and sulphur between the temperatures 290° and 390° were studied.

The following gaseous, liquid and solid products were obtained:—

Gaseous:—Hydrogen sulphide, thiophen, and thiophenol.

Liquid:—Carbon disulphide, thiophen, and thiophenol.

Solid:—Carbon.

Thiophenol is not obtained by any previous workers. The methods followed for separating the products are described.
Further work is in progress.

92. An attempt to prove the constitution of embellic acid.

K. S. NARGUND and D. D. Kanga.

(I) Unsuccessful attempts were made to extract the active principle of the dried fruits of *Embellia ribes* by aqueous solutions of sodium hydroxide and sodium carbonate.

(II) Embellic acid was prepared by a slight modification of the method followed by Hefter and Feurstein.

(III) The following new derivatives have been prepared and analysed.

			M. p.
(a)	A monoacetylal derivative	57°-58°
(b)	A mono semicarbazone	205°-206°
(c)	A di-semicarbazone	255°-256°
(d)	A di-hydrazone	178°-180°
(e)	An oxime	178°

(IV) Further work is in progress to show the existence of a ring structure in embellic acid.

93. Fluorescence in organic compounds. Impurity a most contributory cause.

SIKHIBHUSHAN DUTT, Allahabad.

Eight organic substances which are ordinarily known to be highly fluorescent compounds, such as, quinine, resacetopnone, anthracene, methylacridine, fluorescein, eosin, anthranilic acid and dicyano-quinol were exhaustively purified by various processes including fractional crystallisations sometime exceeding thirty in number. These were thus obtained in conditions practically devoid of all fluorescence. It becomes thus evident that impurity is a most contributing cause of fluorescence of organic compounds.

94. Dyes derived from cinchomeronic acid.

J. D. TEWARI, Allahabad.

Cinchomeronic acid which is an isomer of quinolinic acid, condenses with aromatic amino and hydroxy compounds in the same way as phthalic acid or quinolinic acid (Ghosh, J., 1919, 115, 1101) yielding dyestuffs similar to the phthaleins. Thus condensation products have been obtained for the first time with phenol, resorcinol, m-diethylamido-phenol, phloroglucinol and m-phenylenediamine. In general properties these substances are very similar to the corresponding compounds derived from quinolinic acid, though the tinctorial properties are somewhat weaker in comparison.

95. Some new organo-mercuric compounds.

M. GOSWAMI and P. GANGULY.

Organo mercuric compounds of m-nitrophenol and anthracene have been prepared. m-Nitrophenol-mercuric-chloride is pale yellow in colour, soluble in acetone and alcohol and melts at 184°-186° with decomposition. The anthracene compound is a white crystalline solid, insoluble in acetic acid and benzene, soluble in acetone and melts at 180°-182° with decomposition.

96. Further experiments on the decomposition of unsaturated compounds by nickel.

M. GOSWAMI.

Cinnamic aldehyde and cinnamic alcohol are practically decomposed giving styrolene and phenyl acetylene. Eugenol and isoeugenol remain unaffected. This is in agreement with the generalisation already arrived at:

- (1) That unsaturated chain attached to the benzene nucleus is stable.
- (2) Unprotected CH_2OH and CHO attached to $-\text{CH}=\text{CH}.\text{Ph}$ decompose like the corresponding COOH compound.

97. Studies in the anthraquinone series: Syntheses of anthraquinones related to morindone.

P. C. MITTER and HAROGOPAL BISWAS.

The anthraquinone derivatives occurring in plants appear to conform to certain definite types. Thus, all the anthraquinones present in madder may be regarded as derived from 3-methyl purpurin by permutation and combination of the groups present in it. Similarly the anthraquinones present in chayroot may all be regarded as derived from anthragallol and the anthraquinones of the emodin family may be regarded as derived from 1:3:8-trihydroxy-6-methyl anthraquinone.

From the above, it appeared plausible that the less known anthraquinones associated with morindone might be related to it in the same way or in other words that they might be derivatives of 1:2:5 trihydroxy-6-methyl anthraquinone. Some of the anthraquinones belonging to this type have been studied and it has been shown that the *Soranjidiol* isolated by Oesterle and Tisza from *Morinda citrifolia* is most probably 2:5-dihydroxy-6-methyl anthraquinone. In this connection 1:2-dioxy-6-methyl and 1:5-dioxy-6-methyl anthraquinones and some of their derivatives have also been studied.

98. Studies in the cellulose group—Part I. Chemical examination of water hyacinth and *Excoecaria agallocha*.

H. K. SEN and PATITPABAN PAL.

The various celluloses (α , β , and γ) have been isolated and their hydrolytic decompositions have been studied. Methylation and acetylation and subsequent hydrolysis revealed some relationship of the hemicellulose with the cellulose. The different methods of cellulose isolation have been critically examined, the chlorine peroxide method yielding the largest yield of total cellulose.

99. Jute seeds—*Corchorus capsularis*. Part III. Their chemical composition.

N. K. SEN, Dacca.

The composition of the seed is: moisture 7.1, total ash 6.0; of the total ash, water soluble 24.5, acid soluble 74.2, silica 1.3; total N 2.6, crude protein ($\text{N} \times 6.25$) 26.62, crude fibre 20.76, P_2O_5 1.99 (=33.16 of total ash), alkalinity of water soluble ash (as K_2CO_3) 9.25. Petroleum ether extract 14.72, ether extract 1.36, chloroform extract 1.9, alcohol extract (95%) 15.72, water extract 7.1. Petroleum ether extract yields a light yellow semidrying oil and ether extract yields some fatty acids, a small quantity of sterol and a little oil agreeing closely in character with

that obtained from petroleum extract. The alcoholic extract of the seed yields (1) a quantity of sugar, corresponding to about 3% of the entire seed, (2) a very small quantity of tannin and (3) resinous material. From the resin there is isolated a non-alkaloidal substance (m.p. 176-177°) having an extremely bitter taste. It is crystallised from acetone in thin plates, soluble in most of the ordinary solvent and gives the characteristic colour reactions for phytosterol glucosides (phytosterolene) described by Power and Salway.

100. Oil from the seeds of *Celastrus paniculatus*.

MARGARET J. SOLANKI, K. S. NARGUND and D. D. KANGA.

The drug belongs to the natural order *Celestrineae*.

The yield of the oil was found to be 40 to 45%. When freshly prepared it is yellowish red in colour, transparent, very bitter in taste and having a characteristic odour of its own.

It gives the following analytical data:—

Yield of the oil	40-45%
Sp. gr. at 15.5°	0.9566
Refractive Index ⁿ D at 40°	1.45472
Iodine value	103.01
Saponification value	205.82
Acid value	29.37
Reichert-Meisel value	26.645
Unsaponifiable matter	8.355

Further work on the oil is in progress.

101. Longifolene.

B. SANJIVA RAO.

On repeated treatment with hydrogen chloride, this tricyclic sesquiterpene gives a quantitative yield of a monohydrochloride $C_{15}H_{24}HCl$ m. p. 59-60° (Simonsen, J. Chem. Soc. 1920, 117, 570) showing that the hydrocarbon is homogeneous or a mixture of closely related sesquiterpenes. By treatment with a mixture of nitric acid and glacial acetic acid, a mono-nitro derivative was obtained along with a saturated hydroxy acid $C_{15}H_{24}O_3 \cdot \frac{1}{2}H_2O$, m. p. 165-167° (equiv. by titration 256.1; anhydrous acid m. p. 187°; acetyl derivative m. p. 158°). The nitro derivative on oxidation with dilute permanganate gave a liquid acid and two lactones of the same molecular formula $C_{15}H_{22}O_2$, m. p. 217° and 174-176° resp. (Mol. wt. by Rast's method 243 and 241 resp.).

102. The essential oil from the wood of *Gedrela toona*.

P. PARAMESWARAM PILLAI.

The finely powdered wood yielded 0.4 per cent. of an essential oil which has been investigated. It contains 1-copaene (35 per cent.) cadinene and other bicyclic sesquiterpenes (isocadinene?) of the cadalin group (40 per cent.) and cadinol (20 per cent.).

103. The essential oil from the leaves of *Litsae zeylainca*.

B. SANJIVA RAO.

The essential oil from the leaves is described and has been found to consist of α -pinene (5 per cent.), ocimene (62 per cent.), humulene, hecabolene and a mixture of bicyclic sesquiterpenes belonging to the adalin group (27 per cent.).

104. The fatty oil from the seeds of *Caesalpinia bonducella*, Flem.

M. C. TUMMIN KATTI.

The common physical and chemical characteristics of the oil have been determined. The total fatty acids have been separated into saturated and unsaturated acids by Twitchell's method.

The saturated acids have been examined by fractionating their methyl esters and subsequently determining the saponification value of the latter and the neutral equivalent of the acids liberated. The unsaturated acids have been similarly examined by fractionating their methyl esters and subsequently determining their saponification number and iodine value.

The unsaponifiable material yielded a phytosterol of m. p. 122-23°C and a very small amount of a white crystalline compound of m. p. 55-8°C.

105. Constituents of the seeds of *Caesalpinia bonducella*, Flem.

M. C. TUMMIN KATTI.

The alcoholic extract of the seeds on being separated into various fractions depending upon its partial solubility in the common organic solvents and further examined, has been found to contain the following compounds:—

Petroleum ether extract:—'Bonducin,' the bitter resinous principle which can be obtained only in the form of a white amorphous powder; palmitic and stearic acids and probably arachidic acid; two phytosterols—one melting at 132-3°C and giving an acetate of m. p. 119-20°C and the other melting at 122-3°C and giving an acetate of m. p. 109-11°C; a phytosterolin of m. p. 238-90°C which proved to be identical with ipuranol; a neutral white crystalline compound of m. p. 234-5°C which gave tests similar to those of phytosterols; and an unsaponifiable unsaturated yellow oil.

Ethyl ether and chloroform extracts:—mainly the resinous bitter principle 'bonducin' and some oily material.

Alcoholic extract:—a very small amount of a reducing sugar probably glucose, which gave an osazone of m. p. 205°C; and also a large amount of a non-reducing sugar which on hydrolysis yields a reducing sugar, the latter giving an osazone of m. p. 204-5°C.

The alcohol extracted seed-powder on being extracted with low boiling petroleum ether gave about 10-11 per cent. of a clear tasteless, pale, yellow oil which has been investigated separately.

106. Constitution of the active principle of *Embelia ribes*.

R. KAUL, A. C. ROY, and S. DUTT, Allahabad.

Embelia ribes or *Viranga* as it is called in Bengali, in a finely powdered condition was extracted with organic solvents and the product thus obtained was subsequently purified by fractional crystallisations. The substance was thus obtained in beautiful golden yellow prisms with metallic lustre, melting at 140°. On examination it was found to be a carboxylic acid of the hydro-aromatic type containing two ketonic groups. On oxidation with potassium permanganate it gave a mixture of pelargonic and succinic acids, and on distillation with zinc dust it gave a liquid aromatic hydrocarbon. Further investigation on this substance which has been named embellic acid is in progress.

107. Fatty acids derived from the oil of Neem (*Melia azadirachta*). The so-called margosic acid.

A. C. ROY and S. DUTT, Allahabad.

Neem oil bought from the bazaar as well as extracted from the seeds was saponified by sodium hydroxide in an autoclave and the fatty acids thus obtained were separated from one another by fractional distillation under highly reduced pressure, and also subsequent recrystallisation where necessary. The following acids were thus isolated and definitely identified and they formed 90% of the total fatty acids found in Neem oil: Solid acids:—palmitic and stearic; liquid acid:—oleic. The remaining 10% contained products which could not be distilled even under very high vacuum (0.1 mm) and they became charred during the process of distillation. On examination these were found to consist mainly of resinous matter. No such acid as margosic acid, as isolated and described by Mukherjee and Sen (Journal of Indian Medical Research, 1920) was found to exist in any portion of the fatty acids derived from Neem oil. Even on exactly following the methods described by the authors no acid of the linolic acid series could be obtained. The various constants for the fatty acids as obtained by the previous authors were found to be entirely different from those obtained by us. So the existence of the so-called margosic acid in Neem oil seems very doubtful.

108. Oil from the seeds of *Sterculia urens*.

S. R. BHATE and K. HABIB HASAN, Hyderabad, Deccan.

The seeds of *Sterculia urens* a forest product had been the subject matter of an investigation. The shining black oval seeds weigh about 16.2 gms. per hundred and contain 30% of husks and 70% of kernels. The kernels yield 25.5% of a fixed oil, the defatted residue giving 6% of nitrogen. The pressed oil from the seeds has the following characteristics:—

Specific gravity at 30°C	0.9123
Refractive index at 30°C	1.4650
Sap. value	197.5
Acid value	7.75
Iodine value	66.5

The fatty acids of the oil had the following numbers:—

Neutralisation value	206
Iodine value	66
Melting point	33°C

The examination of the fatty acids by separating into solid and liquid acids by Twitchell's method gave 26% of solid acids with a melting point 70–71°C and 74% of liquid acids giving a dihydroxystearic acid of melting point 143°C on oxidation with alkaline permanganate and yielding no ether-insoluble bromides. The fatty acids so far identified are stearic and oleic acids. Search for other acids if any, is continued. The oil from seeds would form an excellent article of food.

109. The chemistry of indigenous oils and fats. Part I.
The composition of crocodile fat.

P. RAMASWAMI AYYAR and V. V. SIVARAMA IYER.

The fat has the following physical and chemical characteristics:—

Sp. gr. at 45°	=0.9013
μ at 60°	=1.4575
Saponification value	=195.0

Unaponifiable matter=1.7%
Iodine value =84.8

The mixed fatty acids were separated into saturated and unsaturated acids with the following results :—

	Per cent.	I. V.	Mol. wt.
Mixed acids ..	100	81.3	270
Saturated acids ..	34.1	0.0	262
Unsaturated acids ..	65.9	120.0	268

The solid and liquid acids were separately esterified and the esters fractionated and examined.

The following acids have been found to be present. Palmitic and stearic, in the solid acids; and lauroleic, myristoleic, palmitoleic and clupanodonic acids, in the liquid acids.

110. The chemistry of indigenous oils and fats. Part II. The composition of the fixed oil from the seeds of *Vernonia anthelmintica*.

P. RAMASWAMI AYYAR and S. M. PATEL.

The oil of which the seeds contain 18 per cent. has the following physical and chemical properties :—

Sp. gr. at 27° =0.9595
μ at 25° =1.4815
Acid value =24.6
Saponification value =170.5
Unaponifiable matter=6.7 per cent
Iodine value =101.4

The mixed acids were not separable by Twitchell's method into solid and liquid acids. The acids, freed from unaponified matter were therefore converted into methyl esters and the latter carefully fractionated seven times.

The following acids have been found to be present: Palmitoleic, oleic, linolic and a new member of the ricinoleic series of acids, having the empirical formula, $C_{16}H_{30}O_2$.

The constitution of this acid is being studied.

111. The chemical mechanism of the formation of citric acid from glycerol by *aspergillus niger citricus*.

V. SUBRAMANIAM.

Glycerol, when fermented by the mould *aspergillus niger citricus*, has been found to yield citric acid. The chemical mechanism of this change has been investigated and intermediate substances in the transformation glycerol → citric acid have been isolated.

112. The chemical mechanism of the formation of fumaric acid from glucose by *aspergillus fumaricus*.

V. SUBRAMANIAM.

Ehrlich and various other workers have observed the formation of fumaric acid by the action of the mould *Aspergillus fumaricus* on glucose. A careful study has been made of the chemical transformations involved from glucose → fumaric acid. Intermediate products have been isolated and a theory put forward to explain the transformations.

113. Eleusinin, the alcohol soluble protein of ragi (*Eleusine coracana*).

N. NARAYANA and ROLAND V. NORRIS.

A more complete analysis of this protein which constitutes about 10% of the total protein of the grain has been made. (cf. Science Congress Abstracts, 1928). The following results have been obtained:—

Arginine, 2.23 %; Histidine, 1.13 %; Lysine, 0.46 %; Cystine, 1.39 %; Tyrosine, 2.98 %; Tryptophane, 1.59 %; Ammonia, 4.15 %; total dicarboxylic acids (calculated as glutamic acid), 33.51 %.

114. The globulin of Bengal gram (*Cicer arietinum*).

N. NARAYANA and ROLAND V. NORRIS.

The air dry kernel contains about 4 % nitrogen or 25 % protein. ($N \times 6.25$). The best solvent is 6 % sodium chloride solution which extracts about 84 % of the total protein. The protein on elementary analysis showed, N, 17.12 %; S, 0.354 %. On analysis it gave the following figures:—

Ammonia, 2.17 %; Arginine, 10.3 %; Histidine, 0.99 %; Cystine, 0.88 %; Lysine, 7.57 %; Tyrosine, 3.9 %; Tryptophane, 0.41 %.

115. Proteins of 'dal' (*Cajanus indicus*).

P. S. SUNDARAM and ROLAND V. NORRIS.

The nitrogenous matter in 'dal' which is one of the popular food-stuffs consumed in India, consists, for the major part of globulins, a small amount of albumin and only inappreciable amounts of gliadins or glutetins. The globulins can be separated into two distinct fractions, distinguished from each other by their physical and chemical characteristics. All the proteins have been isolated in a state of purity and their detailed analyses attempted in order to assess their probable nutritional value.

116. Studies on starch.

D. NARAYANAMURTI and ROLAND V. NORRIS.

Different methods of separation of amylose and amylopectin present in starch have been compared and a new method evolved. The physical properties of the separated constituents and their behaviour towards diastase have been studied.

117. Studies on lactic fermentation.

G. V. PARAMASIVAN and ROLAND V. NORRIS.

The production of lactic acid during the spontaneous fermentation of rice flour has been investigated. The influence of various factors such as temperature, inorganic salts, etc., has been examined.

118. Studies in enzyme action. Part I. Enzymes of *dolichos Lab-Lab*: Tyrosinase.

D. NARAYANAMURTI, ROLAND V. NORRIS, and
C. V. RAMASWAMI AYYAR.

During an investigation on the proteins of *Dolichos lab-lab* it was found that aqueous extracts of the seed darken on standing, especially in presence of air. This has been traced to the presence of the enzyme tyrosinase, a systematic study of which has been made.

119. Studies in enzyme action. Part II. Cumbu diastase—the optimum pH .

D. NARAYANAMURTI, ROLAND V. NORRIS, and C. V. RAMASWAMI AYYAR.

The effect of age, the nature of the buffer, period of hydrolysis, temperature and other factors on the optimum pH of diastase from malted cumbu, prepared according to Euler's method has been studied.

120. Studies in enzyme action. Part III. Influence of neutral salts on cholium diastase.

D. NARAYANAMURTI and ROLAND V. NORRIS.

The effect of neutral salts on the hydrolysis of starch by cholium diastase at various pH ranges has been studied.

121. Germicidal power of terpene derivatives. Relation between chemical constitution and germicidal activity.

ROLAND V. NORRIS and P. K. DE.

The carboic acid coefficients of a large number of terpene derivatives were determined. Hydrocarbons are all found to be non-germicidal. Compounds containing one of the active groups (OH , CHO , CO , OCH_3 , $COCH_3$, $O-$) are strongly germicidal. The presence of a second "active" group has frequently a depressing action. Unsaturated compounds are more germicidal than the corresponding saturated compounds. An explanation for the inactivity of sesquiterpene derivatives is given.

122. Studies in the germicidal properties of Indian essential oils. Part I.

ROLAND V. NORRIS and P. K. DE.

The investigation was undertaken with the object of ascertaining whether Indian essential oils can be used as disinfectants and secondly whether sesquiterpens which at present form waste product in essential oil industries can be similarly utilised. Many of the essential oils possess a high germicidal power while the sesquiterpenes are all non-germicidal. In disinfectants emulsified by soap, the amount and concentration of the emulsifying agent influence the germicidal activity. Excess of soap has an inhibitory action. The Rideal-Walker coefficient of a number of oils were determined against β -Typhosus.

123. Amylase from *Zea mais*.

V. N. PATWARDHAN.

The amylase was separated from the malted grain by the alcohol precipitation method. The ratio of saccharification to liquifaction is greater with maize amylase than with the barley enzyme but less than that found with cholium amylase. The optimum temperature is about $60^\circ C$ and the optimum reaction pH 5.0. The enzyme passes through a parchment membrane but does not pass through collodion. On dialysis, the enzyme loses its activity which is not regenerated by the addition of salt or dialysate.

124. Studies in amylase from *Sorghum vulgare*. II.

V. N. PATWARDHAN and R. V. NORRIS.

The dextrans I, II, III, and IV, separated at different stages during the reaction between potato starch and amylase derived from malted and unmalted cholum have been further studied. Dextrin I is resistant towards the enzyme from malted cholum, the other three dextrans being hydrolysed by the same. The enzyme from unmalted cholum hydrolyses all the four dextrans and in fact does so in every case more rapidly than the enzyme from malted grain.

125. On the hemolytic behaviour of mixture of hemolytes.

K. C. SEN and N. N. MITRA.

No comparative study in details has yet been made of the hemolytic behaviour of mixtures of hemolytes. This study is however important because it would throw much light on the mechanism of the action of the hemolytes on the membrane of red blood corpuscles. The following gives a summary of the results obtained, but the theoretical aspects are not given :--

(1) An experimental investigation has been made of the hemolysis of sheep's erythrocytes by mixture of hemolytic substances.

(2) It is found that there is no balancing action when mixtures like saponin and taurocholate, saponin and oleate and oleate and taurocholate are used. On the other hand the total action seems to be an additive one.

(3) Acids markedly accelerate the hemolytic action of saponin. They also accelerate the effect of taurocholate in low concentrations, and retard the action of oleate which is due to the formation of less hemolytic oleic acid.

(4) The effect of alkali is in most cases the reverse of that of acid. Saponin and taurocholate hemolysis are retarded in presence of this substance while oleate hemolysis is increased in low concentrations.

126. On the nature of the time-dilution curves in some hemolytic systems.

K. C. SEN and N. N. MITRA.

About 20 years ago MacLean and Hutchinson (Biochem. J., 1909, 4, 369) described an interesting phenomenon which they termed as an hemolytic paradox, namely that under similar conditions the same hemolytic effect can be produced in a given time by widely divergent amounts of some hemolytes, and the time-dilution curves in these cases show a sort of periodicity. A study has now been made of the time-dilution curves of 5 hemolytes in a certain concentration range to find out the existence of any hemolytic paradox in these cases. An interesting phenomenon has been noted that sodium taurocholate shows the hemolytic paradox when the concentration of the red blood corpuscles and that of the hemolyte is comparatively high, but at lower concentrations of the reacting substances, no hemolytic paradox is to be noticed. With acids, alkali, saponin and oleate as hemolytes however no hemolytic paradox was observed within the concentration range studied and the time-dilution curves were normal.

127. Utilisation of rice straw as a source of power alcohol.

D. D. DESHPANDE.

Hydrolysis of rice straw has been carried out under various conditions of pressure and acidity and the influence of these changes on the

yield of alcohol investigated. In all cases a considerable amount of unfermentable carbohydrate remains and the nature of this is under investigation.

The residue of the straw after hydrolysis has been utilised for paper making. Direct bleaching with alkaline hypochlorite can readily be effected without previous treatment with alkali. Such paper without filling or sizing could be used as filter paper.

128. Nitrogen fixation in soils by azatobacter under ordinary conditions and in presence of varied proportions of different soils.

N. N. INUGANTI and K. HABIB HASAN, Hyderabad, Deccan.

This paper is the continuation of the one read last year before the Indian Science Congress at Calcutta. Further investigations were carried out to amplify the last results and to study the inhibiting properties of alkaline soils in nitrogen fixation.

OBSERVATIONS:—

- (1) The more active nitrogen organisms are found near the surface of the soil and up to a depth of 6 inches. Deeper down they are less active.
- (2) Nitrogen fixation is vigorous in mannite solution.
- (3) Higher percentage of sodium carbonate and sodium bicarbonate in the soil diminish their activity but does not destroy them.
- (4) Pure cultures are easily effected by the alkaline solution than the mixed soil culture.
- (5) Chalk was found to be essential to maintain the vigorous activity of the pure cultures.

129. A few observations on the process of making ghee and its effect on the legal standards.

A. D. STEWART and N. L. BANERJEE, Calcutta.

Ghee is prepared generally in two ways, viz., (1) from butter churned from raw milk, (2) from butter churned from 'dahi' (sour milk) made from boiled milk and kept for several days. Next, the butter is melted and heated to different degrees of temperature for clarification to produce ghee. Formerly there was a misapprehension that all these factors in making ghee might alter its analytical values. Experiments made in the laboratory to elucidate this point go to show that the process of making does not in the least affect the Reichert-Wollny value and the butyromicrorefractometer reading—the two legal standards prescribed by the Bengal Food Adulteration Act.

It has been found that ghee prepared from 'dahi' has got the peculiar aroma, while the one from raw milk has none. On keeping 'dahi' its lactic acid content increases with the increase in the yield of butter accompanied by the simultaneous decrease of surface tension of its serum. This decrease of surface tension enhances the effect of lactic acid which is responsible for the increased yield of butter.

From the analogy that buffalo milk with its higher fat content possesses a higher Reichert-Wollny value than cow's milk, it was thought that there might be a relation existing between the initial fat content of individual cow's milk and its Reichert-Wollny value. From the examination of 12 samples of such milk no definite relation could be found out.

130. A note on mixed solvents for shellac.

M. RANGASWAMI and M. VENUGOPALAN.

After indicating briefly the importance of a systematic study of the properties of shellac, the paper deals with the viscosity and solvent power of shellac solutions in mixed solvents.

Mixtures of methyl and ethyl alcohols, methyl alcohol and propyl alcohol and of ethyl alcohol and ethyl acetate are experimented with and the changes in the times of flow of 20% shellac solutions and their solvent power numbers studied with reference to a few theoretical findings and also from the point of view of practical application.

The relation of viscosity to solvent power number has been shown and the importance of a simultaneous consideration of both properties indicated.

131. Action of chlorine peroxide on jute fibre.

J. K. CHOWDHURY and P. C. MAZUMDAR, Dacca.

Jute fibre, freed from fatty and resinous matters, was treated with solutions of chlorine peroxide in water. It has been found that two or three washings with 2.5% chlorine dioxide solution removes lignone matter very satisfactorily, no subsequent washing with sodium sulphite as recommended by Schmidt and Graumann for wood, being necessary in this instance. This treatment leaves only traces of lignone in the fibre as shown by treatment with highly concentrated hydrochloric acid. In a single operation, both raw cellulose and lignone in jute can thus be estimated and this fact coupled with the ease with which the operation is carried out, greatly simplifies the methods of estimating these substances. The yield of raw cellulose is higher than that obtained by any other method as all the other components of jute except lignone remain practically unaffected if treatment with sodium sulphite is avoided. The yield of α -cellulose is also higher than that obtained from jute subjected to the action of chlorine according to the method of Cross and Bevan.

132. The estimation of small quantities of gelatin in solution.

J. G. KANE.

The Pulfrich refractometer fitted with a double cell has been found suitable for determining small concentrations of gelatin. The solution to be examined is placed in one half of the cell and a solution of known concentration or water in the other. By taking readings on the micro-meter, differences in concentration of 0.01 per cent can be detected. The method is rapid and exact adjustment of temperature is not necessary. The accuracy is from 5 to 10 times as great as that attained by use of the immersion refractometer.

133. Note on uric acid estimation.

B. BANERJEE and S. RANGANATHAN.

Uric acid has long been identified as an important product of animal metabolism, but its estimation even to-day is far from satisfactory. Before the year 1912 the only method was that of Folin and Schaffer which was tedious and empirical. However, since the introduction of phosphotungstic acid as a colour reagent for uric acid several workers have applied this method with improvements in technique and modifications for the determination of uric acid in blood and urine. In connexion with an investigation on renal stones it was desirable to determine the uric acid content which may be anything between 0 to 99%. The

direct volumetric methods of Curtman and Lehrman, and Morris have not been satisfactory, and we tried the different colorimetric methods for our purpose. Using the Benedict and Francke, or the Folin and Wu method even under the best conditions we find that with stones though the majority of them give values for the uric acid which approximate to those deduced for nitrogen content, still the error, even allowing for the inherent errors of the colorimetric method, is very large. The defect lies in the reagent, its varying composition under slightest different conditions of preparation. Fading of colour, and interfering colour-producing substances under examination contribute not a little to the inefficiency of the method. It would be a great help to biochemistry if a specific process of quantitative estimation of uric acid could be devised.

134. A new method for the estimation of methyl alcohol in wood spirit.

C. VARADHAN.

A new gravimetric method has been worked out for the estimation of methyl alcohol in wood spirit. The method consists in converting the methyl alcohol into the methyl ester of 1 : 3 : 5-dinitrobenzoic acid and isolating and weighing the ester, which is a solid. The advantages of the method over the usual methyl iodide method are that the methyl esters present in the spirit are not estimated and the manipulations are much less troublesome.

135. A simple test to detect the presence of mineral oils in vegetable oils.

A. GUTHRIES.

To detect adulteration of this type the sample is usually tested chemically and takes some time and necessitates a laboratory and chemical apparatus. A simple and quick method which gives results approximately coinciding with that of chemical test, has been devised in this laboratory, which can be done without costly apparatus and gives the buyer a fairly reliable idea of the sample in a few minutes.

This method consists in burning a piece of cotton wool soaked in the sample of oil and observing the flame, if the sample is pure, then the flame burns bright and clear without any smoke and if adulterated with mineral oil the flame burns reddish and gives off varying amounts of smoke according to the quantity of mineral oil present.

A quantitative determination can be easily made by comparing this flame with that of other produced by standard samples of oils containing known quantities of mineral oil.

This test can be also used for most animal oils and is quite useful in detecting white mineral oil in ghee.

136. A new method of preparation of carbon and its direct estimation in carbonates.

G. SAMBAMURTI and N. L. NARASIMHAM, Rajahmundry.

The carbonate is heated with excess of yellow phosphorus and the mass heated with water; the liquid is filtered off and the residue washed, dried and weighed, affording a new method of the direct estimation of carbon and its preparation in the pure state for use in laboratories.

137. Active aluminium.

G. SAMBAMURTI and N. L. NARASIMHAM, Rajahmundry.

Activation of aluminium by amalgamation in addition to the conditions already noted in the last year's paper it has been found that the action ceases altogether when the pressure is below a certain limit and increases with pressure above this minimum.

138. Investigation on fat-liquor emulsifying power of sulphonated castor oil.

B. M. DAS, B. B. DHAVALE, and B. N. PAUL.

Chrome leather requires incorporation of some fat into it after tanning for suppleness. This incorporation is usually done by treating the tanned and neutralised leather with an emulsion of oil, which is technically called "Fat-liquor." Formerly oil used to be emulsified for this purpose with soft soap but this soap-oil emulsion not having proved quite satisfactory in practice, sulphonated oils have come into vogue for emulsifying oil. Sulphonated oils differ in their capacity for emulsifying oils and the present investigation was undertaken to determine the capacity of sulphonated castor oil to emulsify castor oil. Experiments detailed in the paper have shown that two parts of sulphonated castor oil can emulsify one part of castor oil and the emulsion so formed will not throw away much oil even standing for a week.

139. On an evidence of the James Thomson state of matter.

SATYENDRA RAY, Lucknow.

The way in which the graph of the Van der Waal's equation runs is well known. The portion between the maximum and minimum in the graph is not experimentally obtained although prolongations of the curves towards these maximum and minimum from where the curve breaks into a straight are experimentally found.

Mattauch in Vienna claims to have found in Ehrenhaft's laboratory values of the electrone identical with that given by Millikan. The mathematical analysis giving this agreement, however, has the drawback that the density of the particles is found not to be constant but to vary within a range of 1 : 19 for the different particles of the same substance.

The present writer in *Koll. Zeit.*, XLIV, 186, 1928, has shown that the particles are hollow bubbles with a gas core held within a film of selenium. When Mattauch's values of pressure and radius are plotted in a graph as y and x co-ordinates the graph resembles that corresponding to Van der Waal's equation. As volume is proportional to the cube of the radius the nature of the graph could be unaltered, except for a change of scale and a distortion. The author therefore believes that we have here an experimental evidence of the James Thomson part of Van der Waal's gas equation.

140. A note on osmotic pressure.

SATYENDRA RAY, Lucknow.

What Lecher's "Lichtzug" is in Ehrenhaft's "negative radiation pressure," that is "osmotic pressure" in the kinetic theory. The negative character of the "osmotic pressure" is, generally, not properly realised. As $p=1/3 nmc^2$ there is no provision for such a negative pressure in kinetic theory. In this connection it is refreshing to note the intellectual honesty with which the enunciator of the Law of Distribu-

tion of Velocities amongst the molecules confessed the possibility of explaining the whole behaviour of gases by the second term of the virial of Clausius without any aid of a kinetic theory. In this admission of Maxwell lies the explanation of the "osmotic pressure" exerted by the particles of a dissolved substance.

141. On the "atomicity" of the electric potential of colloidal silver in the recent work of O. Trauner in Vienna.

SATYENDRA RAY, Lucknow.

From Trauner's own observations it is shown that the values of e/a for the different particles exhibit a law of atomicity.

142. On the compressibility of water vapour before and after condensation.

BABU RAM KAPILA.

(Communicated by Satyendra Ray.)

The compressibilities have been compared by regarding the condensed liquid to be N spherical drops of the water vapour itself enclosed within a membrane of surface tension T pertaining to the temperature at which condensation takes place. It is found the vapour in the condensed state is more compressible than the vapour in the gaseous condition and that the value of N increases with temperature.

143. On the synthesis of uric acid. Part I. Action of urea on oxalyl diurethane.

P. C. GUHA and M. N. RAMASWAMY.

The available methods for the synthesis of uric acid of Behrend and Roosen, Traube and of Fischer are more or less complicated, the starting material in each case being not easily obtained. An attempt is being made to synthesise uric acid and its derivatives, by simpler and much more direct methods starting from oxalyl-di-urethane.

With the object of obtaining carbo-oxalyl-diurea, oxalyl-di-urethane was condensed with urea. It was found that besides the expected compound, there was also formed oxalyl-di-biuret.

Various attempts are now being made to convert carbo-oxalyl-diurea into uric acid.

144. Hetero-ring formations with ethylxanthic formic ester.

P. C. GUHA and D. N. DUTTA.

Ethylxanthic formic ester (Et.OOC.S.CSOEt) reacts with aromatic amines to yield disubstituted amides (RNH.CO.S-CS.NHR), with hydrazines it gives phenylthiocarbazinic ester to the complete exclusion of the equally expected phenylcarbazinic esters. With semicarbazide and 4-R-thiosemicarbazides it yields thiocarbethoxy and carbethoxy derivatives which can be made to yield thiobiazole and triazole derivatives by the action of suitable ring-closing agents. Phenylenediamine gives thiocarbethoxy-phenylene-urea, carbethoxyphenylenethiourea and phenylenethiourea. Ethylenediamine yields ethylenethiourea ethylene urea and the monothiodiester. Naphthylene diamine yields two interesting seven membered endoxy compounds.

145. Lengthened *ortho*-diderivatives of benzene and their ring closure.

P. C. GUHA and T. N. GHOSH.

*ortho*Phenylene-diaryl-dithiocarbamides $\text{RNH-CS-NH-C}_6\text{H}_4\text{-NH-CS-NHR'}$ ($\text{R,R' = Ph, tolyl, xylyl, naphthyl etc.}$) yield arylaminothioheptadiazine compounds; the corresponding dialkyldithioureas yield dialkylaminothioheptadiazine compounds by the action of ring closing agents. The mixed aryl-alkyldithioureas, however, give similar compounds *o*-phenylenediurea gives diketo-benzoheptatriazine, but peculiarly enough the corresponding diphenyldiurea remains unchanged on being boiled with HCl. Phenylene diphenyl monothiodiurea $\text{Ph-NH-CS-NH-C}_6\text{H}_4\text{-NH-CO-NH-Ph}$ obtained from $\text{NH}_2\text{-C}_6\text{H}_4\text{-NH-CS-NHPh}$ and PhNCO give monothiodiketo-benzo-heptatriazine; $\text{PhNH-CS-NH-C}_6\text{H}_4\text{-N:CHPh}$ obtained from the foregoing amino compound and benzaldehyde, yield benzoheptathiodiazine, on being oxidised with FeCl_3 . *o*-Aminophenyl-aryl-thioureas yield phenylenethiurea, whereas *o*-aminophenylalkylthioureas give benzothiazoles.

146. Formation of heterocyclic compounds from hydroxymethylene cyclohexanone.

P. C. GUHA and B. K. MENON.

Urethanes and dithiourethanes react slowly at the ordinary temperature with hydroxymethylene cyclohexanone to yield 2:4-benzoxazine and 2:4-benzthiazine derivatives respectively. They are insoluble in alkali and do not form acetyl or benzoyl derivatives. Thiosemicarbazides and methyl dithiocarbaminates yield thiocarbonamides and methylthiocarboxylate derivatives of tetrahydroindazole. Further work towards the synthesis of octahydro-acridine as also the corresponding sulphur and oxygen compounds from methenyl-bis-cyclohexanones is in progress.

147. Studies in sulphur containing dye-stuffs. Part I—Derivatives of aryl and alkyl sulphido diphenylmethane.

M. V. BETRABET and G. C. CHAKRAVARTI, Bangalore.

In an attempt to synthesise phenylthio-xanthenes by condensing hydroxybenzhydrols with aromatic mercaptans by means of fused zinc chloride highly insoluble red substances containing zinc in the molecules were invariably obtained. Work is in progress to find out the constitution of these compounds.

When concentrated sulphuric acid was used as the condensing agent, the reaction seemed to take a different course altogether. Generally two types of compounds were isolated: (A) acidic, considerably soluble in water and alcohol, and containing a sulphonic acid group; (B) neutral and insoluble in water and alcohol.

The estimations of the percentages of C, H and S, the analysis of K and Ag salts, and a study of the properties indicate that the hydrogen of the mercaptanic group enters into the reaction in preference to that of the benzene ring.

A probable course of the reaction has been suggested.

148. Synthesis of dicoumarins.

R. N. SEN and D. CHAKRAVARTI, Calcutta.

Fittig (*Ber.* 18, 2525) and Dyson (*Jour. Chem. Soc.* 1887, 51, 62) synthesised dicoumarin from salicylaldehyde and succinic aldehyde or sodium succinate. Another type of dicoumarin, dimethyl-dicoumarin different in constitution from that of Fittig, was synthesised in extremely

poor yield by Hantzsch and Zurcher (Ber. 20, 1929), by condensing one molecule of resorcin with two molecules of acetoacetic ester in one operation.

It has now been found that resorcin and similar polyhydroxy compounds do not react satisfactorily with two molecules of acetoacetic ester simultaneously, the main product being hydroxy-coumarin. The condensation of a second molecule of acetoacetic ester or malic acid with the pure hydroxy-coumarin however takes place readily yielding a compound of Hantzsch and Zurcher type in fairly good yield. Several such dicoumarins have now been synthesised by condensing umbelliferone (resorcin + malic acid), daphnetin (pyrogallol + malic acid) and homo-umbelliferone (orcin + malic acid) with a second molecule of malic acid, and also by condensing β -methyl-umbelliferone (resorcin + acetoacetic ester), β -methyl daphnetin (pyrogallol + acetoacetic ester) and β -methyl-homo-umbelliferone (orcin + acetoacetic ester) with a second molecule of acetoacetic ester or malic acid. These dicoumarins are difficultly soluble crystalline substances with high melting points, the lactone rings being usually very stable.

The condensation of *p-p'*-dihydroxy-diphenyl with acetoacetic ester or malic acid with the object of obtaining another type of dicoumarins (true) is also under investigation.

149. Condensation of urethane with resorcinol.

R. N. SEN and A. MOOKERJEE, Calcutta.

In continuation of the condensation of esters with resorcin (paper No. 140 Indian Science Congress 1928), urethane has now been condensed with resorcinol in the presence of zinc chloride by heating to 170°-180° C yielding a pyronine dye. The sodium salt of the product dyes wool and silk beautiful golden yellow shades. The analytical results agree with the formula $C_{13}H_9O_3N$. It is interesting to note that the compound does not evolve nitrogen with nitrous acid and may therefore be assumed to tautomerise to another form.

Similar condensations with substituted urethanes are in progress.

150. A new synthesis of oxyquinazolines.

T. BHATTACHARYA, P. K. BOSE, and J. N. RAY, Calcutta.

Acetyl urethane condenses with *m*-toluidine and *m*-ansidine in presence of phosphorous pentoxide in xylene solution to yield 4-oxyquinazolines. The reaction failed in the case of other aromatic amines. Acyl, benzoyl and propionyl derivatives of aromatic amines readily condense with urethane in boiling xylene solution in presence of P_2O_5 yielding oxyquinazolines. The reaction is general and the yields are satisfactory. The quinazolines derived from *m*-toluidine and acetyl urethane is identical with that derived from urethane and aceto-*m*-toluidide. A scheme of the reaction has been suggested.

151. Benzidine rearrangement in heterocyclic series. Part III.

B. C. DAS-GUPTA and P. K. BOSE, Calcutta.

1- α -Naphthyl- and 1-*m*-nitrophenyl-thiosemicarbazides react with halogenated ketones to form hydrazo compounds which readily undergo benzidine transformation under the influence of mineral acids. The acids have, however, hardly any action on the products derived from the other two nitrophenyl-thiosemicarbazides, which readily dissolve in alkalis or ammonia with a deep violet colour. The constitution of these compounds is under investigation.

152. Reduction of mercuric chloride by glycerine.

M. GOSWAMI and P. GANGULI.

While attempting to prepare some organo-mercuric compounds by means of HgCl_2 and glycerol it was found that under certain conditions HgCl_2 became reduced to Hg_2Cl_2 and practically no yield of organo-mercuric compound was obtained. Studies were then instituted as regards the influence of glycerol on the reduction of HgCl_2 at varying temperatures under different conditions. The following results were obtained:—

Temperature.	% of conversion.				
	HgCl_2 and glycerol and water.	HgCl_2 and glycerol and water (under pressure).	HgCl_2 and glycerol.	HgCl_2 and glycerol (under pressure).	HgCl_2 and anhydrous glycerol.
30° (room temp.)
60°-65°	0.12
100°	0.15	0.3	0.33
120°-122°	..	0.36	1.08
150°-155°	0.65	..	46.71	50.2	52.91
180°-182°	88.0

During the reaction much gases were evolved which were absorbed and the residual liquid in the flask contained glyceric aldehyde. Formaldehyde and acrolein were the constituents of the absorbed gases which represented about 13% conversion calculated on the amount of glycerol used. A probable scheme of the reaction has been suggested.

153. Interaction of aromatic amines with cyclohexanone carboxylic ester.

H. K. SEN and UMAPRASANNA BASU.

When 1 mol. of ethyl cyclohexanone carboxylate and 2 molecules of aniline, toluidine, xylylene, naphthylamine, etc., are heated together for several hours at 160°-170°, the product isolated is not an anilide or anilide, but pure carbanilide derivatives. A probable scheme of the reaction has been suggested. At first the expected anilide is formed which has been isolated in several cases, but on longer heating the carbanilide is produced in good yields.

154. *Terminalia pallida* as a tanning material.

K. S. CHOUDARY and E. YOGANANDHAM.

The fruits of *Terminalia pallida* (a variety of myrobalans, which is very often mistaken for myrobalans, *Terminalia chebula*) is found to contain about 20% of tannin. An infusion of the fruit gets mouldy very quickly and consequently suffers loss in tannin on keeping as in the case of *Terminalia chebula*. It does not produce as much acid as *Terminalia chebula*.

155. Influence of light on the coagulation, electric conductivity and the absorption spectra of some colloids.

MISS ROY and N. R. DHAR.

1. Coagulation experiments show that sols of ferric hydroxide, chromium hydroxide, zirconium hydroxide, ceric hydroxide prepared in the hot condition, vanadium pentoxide, and manganese dioxide become less stable on exposure to light. On the other hand sols of prussian blue, cupric ferrocyanide, mastic, and gum dammar are stabilised on exposure to light. Arsenious sulphide becomes unstable towards mono- and bi-valent electrolytes but stable towards tri- and tetra-valent cations. Hence sols can be divided into two classes, in one class, the stability increases and in the other the stability decreases on exposure.

2. Ceric hydroxide sols prepared in the hot and cold conditions, Oden sulphur sols prepared in excess of acid or thiosulphate, manganese dioxide sol, cadmium sulphide sol and a dilute sol of cupric ferrocyanide have been coagulated on exposure to sunlight.

3. The electric conductivities of the sols of $\text{Fe}(\text{OH})_3$, $\text{Cr}(\text{OH})_3$, $\text{Zr}(\text{OH})_4$, $\text{Ce}(\text{OH})_4$ hot, MnO_2 , As_2S_3 , prussian blue, cupric ferrocyanide increase on long exposure to light whilst the specific conductivities of vanadium pentoxide, of gum dammar and mastic decrease on exposure.

4. Measurements of the absorption spectra of the exposed and unexposed sols show more marked absorption of light in the cases of ferric hydroxide, As_2S_3 and prussian blue and less absorption in the cases of gum dammar and mastic. Hence it is inferred that the particles in the former class of sols agglomerate and in the latter case disintegrate on exposure to light.

5. In most cases the light effect is an accentuation of the time effect.

6. The coagulation of a sol by light is due to two causes (1) decomposition of the stabilising ion and (2) loss of reactivity of the particles of the sol. The former is possibly the more important reason.

156. Behaviour of alcoholic sols of gelatine.

S. N. BANERJI and S. GHOSH, Allahabad.

Coagulation of acidic and alkaline gelatine in alcohol has been determined with different electrolytes. The acidic gelatine in alcohol behaves as a positively charged sol and greater amounts of KCl are required to coagulate the sol in presence of MgCl_2 , BaCl_2 , $\text{Al}(\text{NO}_3)_3$ and HCl than the amount required to precipitate when KCl is used alone. The antagonism with different cations is in the following decreasing order.



'Ionic antagonism' is developed to a lesser degree when the sol is coagulated with a mixture of KCl and K_2SO_4 .

When the sol is diluted with the same concentration of alcohol as present in the original sol it becomes more stable towards electrolytes like KCl and MgCl_2 containing a monovalent anion.

Alkaline gelatine in alcohol behaves like a negatively charged sol and develops 'ionic antagonism' when coagulated with mixtures of KCl and K_2SO_4 , and KCl and $\text{K}_4\text{Fe}(\text{CN})_6$, the antagonism being more developed with $\text{K}_4\text{Fe}(\text{CN})_6$ than with K_2SO_4 . The sol also becomes stable on dilution.

It is, therefore, concluded that the positively charged sol of gelatine can adsorb cations and the negatively charged one can adsorb anions, and this results from the amphoteric nature of gelatine. Loeb has shown that the positive charge on a gelatine film can be increased by the addition of LaCl_3 , CeCl_3 , etc., whilst negative charge is increased in presence of sodium ferrocyanide.

Loeb could not detect the adsorption of cations on the acid side and anions on the alkali side of gelatine, because in the course of washing the highly adsorbed water displaced the adsorbed cations and anions. That substances adsorbed in large amounts can displace the substances adsorbed in small amounts from adsorbents is well known.

157. Sensitization of resin sols by proteins and carbohydrates.

L. S. BHATIA and S. GHOSH, Allahabad.

1. Sols of mastic and gum dammar are sensitized towards their coagulation by KCl in presence of gelatine, starch and cane sugar. The sensitization is more marked with gelatine than either cane sugar or starch.

2. In all cases the sensitization, increases when the amount of gelatine, starch and cane sugar added is gradually increased and passes through a maximum, when the further increase in the amounts of gelatine, starch and cane sugar stabilise the sol.

3. Both mastic and gum dammar are more acid than isoelectric gelatine. When gelatine is added to the resin sols, the pH value gradually diminishes and passes through a minimum. It is observed that minimum pH value coincides with the maximum sensitization of the sols towards their coagulation by KCl. Similar results are obtained with cane sugar and starch.

4. It is concluded, that the sensitization of resins sols in presence of gelatine occur from the adsorption of hydrogen ion given out by the hydrolysis of the resins and thus forming positively charged gelatine, which exerts a coagulating effect on the negatively charged sol. When more gelatine is added, the negatively charged protein is in excess and thus stabilises the sol.

5. The sensitization observed in presence of carbohydrates results from the depression of the hydrolysis of the resinous matter and thus decreasing the concentration of the complex organic acid, which is a stabiliser. When larger quantities of these carbohydrates are added the stabilisation as is generally observed with these carbohydrates and many other sols becomes prominent.

158. Action of quinolinic acid on aromatic diamines.

A. K. DAS and I. B. SARKAR.

A study was made of the action of the quinolinic acid on phenylene diamine (i) in the dry way and (ii) in the wet way in alcoholic solution.

(i) Distinct compounds were formed with ortho, meta, and para diamines, but the action of ortho diamines seemed to be a bit more complicated.

(ii) An additive compound was isolated from the ortho diamine but no definite compound could be obtained with meta and para diamines, although the solution became distinctly fluorescent.

159. An examination of the constituents of the "Neem" leaves.

R. N. SEN and I. B. SARKER.

Melia azadirachta or "Neem" is a common tree in India. Its leaves are largely used in medicine.

Leaves were extracted with water and also with alcohol and the constituents examined. (i) An organic acid, (ii) a soluble calcium salt of an organic acid, (iii) glucose and (iv) the bitter principle were obtained. The bitter principle has not yet been isolated in the pure state. Former investigators did not find nitrogen in the bitter principle but the present

investigators have got as much as 4% of nitrogen even in the impure bitter principle. The work is still in progress.

160. A new method of making nickel catalyser.

BANESVAR DASS and ATUL CHANDRA DUTTA, Jadavpur.

During the study of catalytic hydrogenation of oils and fats, the preparation of nickel catalyser was undertaken by an electrochemical process to avoid the use of sulphur or chlorine compounds or any other compound which are catalytic poisons.

Nickel in the form of turnings obtained from 99-100% pure nickel plates was suspended in a cotton net bag around an anode of sheet nickel. Voltage and current impressed on the electrolytic bath were regulated by means of a variable resistance put in series with it. Edison battery was used as the source of current. A solution of sodium carbonate was used as the electrolyte.

After a series of experiments had been performed to find out the more suitable working conditions, the following were the bath characteristics:—

Electrolyte:—0.1 N sodium carbonate solution.

Anode:—Nickel turnings in one cotton net bag around a nickel plate.

Cathodes:—Two sheets of nickel.

Diaphragms:—Two sheets of asbestos paper, 1/32 inch thick.

Current:—0.8 amp. to 1 amp.

Voltage:—2.5 to 3 volts.

Anode surface:—64 sq. cm.

On passing current for 48 hours the surface of the turnings was completely oxidised into black nickel oxide.

The commercial feasibility of the process and its application to catalytic hydrogenation are now being studied and the results will be published later on.

161. The system mercury-sulphur.

Q. A. MANSURI, Aligarh.

This system has been investigated both thermally and microscopically. A sharp break occurs in the liquidus at about 86% Hg, pointing to the compound HgS. The system has been investigated up to 30% of S. It is hoped that further work will reveal the formation of more sulphides of mercury and will throw some light on the different colours of HgS.

162. Analysis of some common Calcutta bazaar pulses.

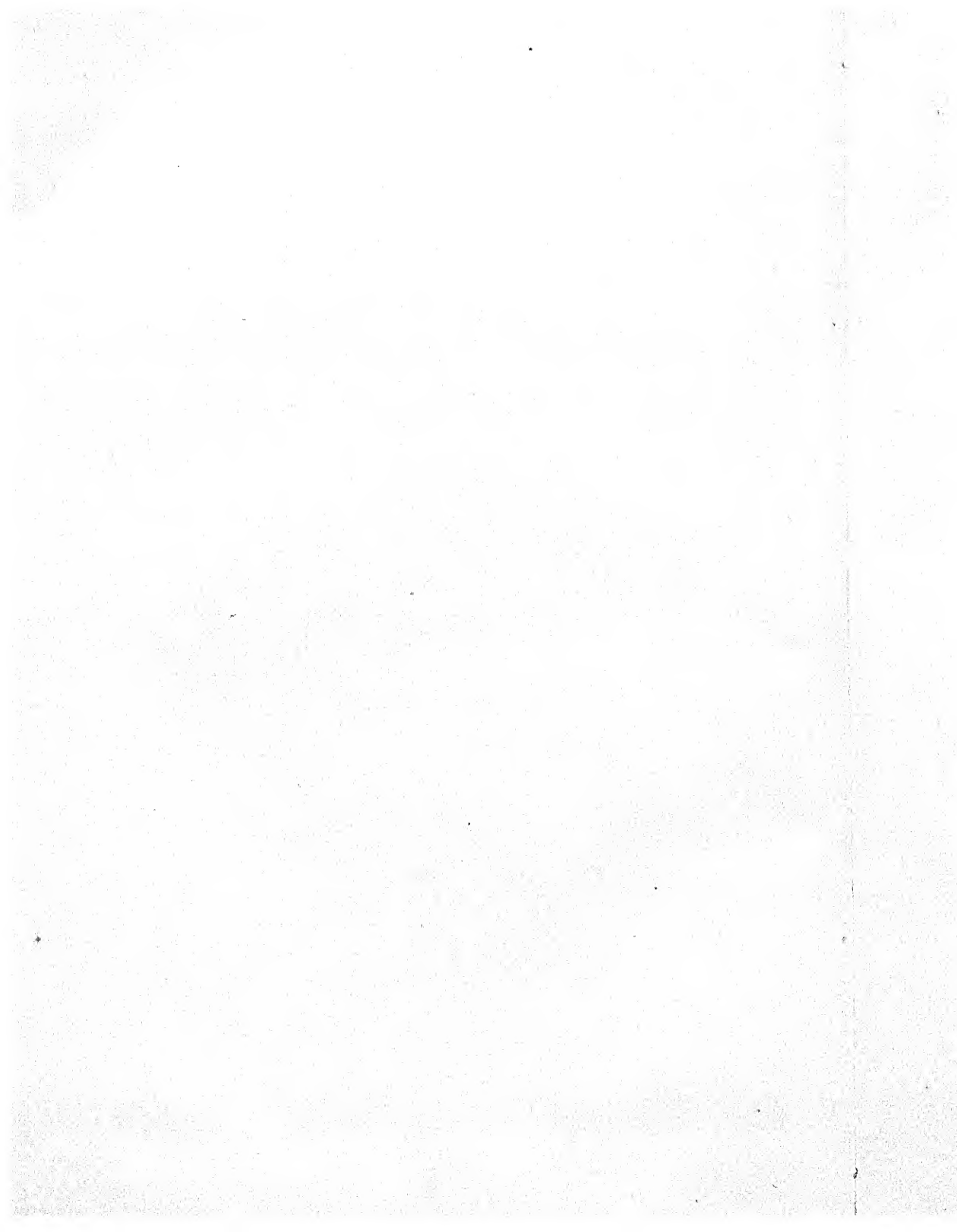
N. C. NAG, H. N. BANERJEE and K. BOSE.

In the course of some work on enzymes, which is in progress at the Bose Institute, it was found necessary to re-examine some of the various analytical results previously obtained by different workers. Our figures are found to agree with those given by Dr. Leather of Indian Agricultural Department. The up-country pulses are slightly richer in oil and poorer in moisture; this is to be expected from the climatic conditions of Calcutta and Dehra Dun. Our results will be found interesting in this that while Dr. Leather and others have given the carbohydrate values merely by difference from the percentage of other proximate constituents determined, we have tried to reduce this undetermined portion to the minimum, by determining the sugar convertible portion as far as possible and showing this as starch. In none of the samples examined by us have we found the mineral portion much above 3%, and it was often much lower. A few of the results are given below:—

	Mois- ture.	Fat.	Proteids (N deter- mined).	Starch (from sugar).	Woody Fibre.	Min- eral.	Total.
CHHOLA.							
Bose Insti. ..	10.01	4.20	19.14	55.27	6.40	3.01	98.03
Dr. Leather ..	9.98	4.39	18.14	57.94* (by diff.)	6.40	2.95	
KRISHN MUG.							
Bose Insti. ..	12.85	0.71	23.52	52.58	6.01	3.34	99.01
Dr. Leather ..	9.48	1.87	23.56	56.29* (by diff.)	4.40	4.02	
Dr. C. L. Bose	10.80	1.40	22.20	55.50* (including woody fibre).		5.80	
BLACK KALAI.							
Bose Insti. ..	11.60	1.00	23.40	51.24	5.84	3.16	95.28
Dr. Leather ..	8.57	1.07	22.50	58.85* (by diff.)	4.24	3.99	
Quoted by							
Dr. C. L. Bose	10.10	2.20	22.70	55.80* (including woody fibre).		9.20	

The figures marked above by * were admittedly obtained by difference from 100, and has therefore but little significance.

Fuller details with other results will be published later on.



Section of Zoology.

*President :—*LT.-COL. F. C. FRASER, I.M.S.

Presidential Address.

"THE PERIODIC EBB AND FLOW OF LIFE."

When I received the invitation to function as president of this important section of the Indian Science Congress, no one was more surprised than myself. I was at once flattered and astonished that such a honour should have been offered to a mere amateur in zoology especially when there were so many eminent scientists here in India, more greatly entitled to serve as president. When I looked up the list of illustrious names of those who had presided at former meetings, I was the more diffident at accepting the honour; an amateur must always experience such a feeling when asked to preside over a gathering of experts and specialists of a subject in which he himself merely dabbles.

Fortunately for me there is a wonderful fraternity existing amongst zoologists, and although terrible conflicts of opinion may rage over some trivial detail of classification, distribution or I wot not, tolerance and amiability are the keynotes of the society. I can only think that in choosing me for the honour, the Congress committee had it in mind to honour, recognize and encourage the small band of amateur zoologists in this country, and if that be so, then I thank the Committee for this graceful recognition of our poor efforts. Thus I feel emboldened to address my more learned confreres on a subject about which they know far more than I do.

Having accepted the presidentship, I was confronted with two difficulties, the one to find time to attend to the copious correspondence which was suddenly thrust upon me, the second to choose some suitable subject on which to build my address. I must admit that the second difficulty gave me much anxious consideration and, probably, several sleepless nights. Should I keep to my own subject Odonatology, or should I brave all and attempt to discourse on one with which I was far less familiar, but which would serve to point a moral. In looking about for the latter, I came on a letter written to me some time last year by my old friend and guide Mr. Bainbrigge Fletcher, in which I noted the following sentence:—

"I suppose that all species have their years of plenty and their lean years"—this in reference to some species of dragonflies which he had been collecting for me, and which he had noted to be extremely scarce in Shillong as compared

to former years. Here then was a fitting subject, which I might entitle "The Periodic Ebb and Flow of Life," and which, if I could find time, I might be able to work up into a suitable address. Unfortunately my time has been very fully taken up, so that I have been unable to look up the many references necessary to the study of so profound a subject. Most of what follows, therefore, has been culled from my own experience, and the instances cited are the results of my own observations; thus, in all probability, I shall come into conflict with trained zoologists and biologists.

THE PERIODIC EBB AND FLOW OF LIFE.

All collectors of natural objects, whether they be lepidoptera, coleoptera, or other insects, or birds or plants, etc., must have noticed that some years are characterized by the fecundity of species, whereas other years are marked by a corresponding sterility. So well known is this, that a lepidopterist will remark to you,—“This has been a very good year for butterflies,” or a coleopterist may remark,—“It has been a very poor year for beetles.”

How few of us have ever paused to reason why this should be? This Ebb and Flow of Life! What chain of circumstances combines to render one year inimical to reproduction and another year to fecundity?

It becomes necessary here to define exactly what I mean by the Ebb and Flow of Life, because in the history of every race, be it of man himself or of the lowest unicellular organism, may be traced two different types of curve. There is the main curve rising gradually to its zenith and then falling more or less steeply, which represents the entire history of a race from its origin to its final extinction, and there are the secondary oscillations or curves which occur in the course of the main curve, representing periods of abrupt increase and decrease. It is to differentiate these two types of curve that I have added the adjective and designated the ebb and flow as periodic. I would, therefore, define the term “Ebb and Flow of Life” as the series of increases and decreases in the numbers of any species, representing a temporary upsetting of the balance of Nature and characterized by migration of all forms of life, as instanced by many historical emigrations of man (Alexandre's invasion of India, Exodus from Egypt, Pilgrim Fathers, Trek of the Boers beyond the Vaal, etc.), flighting of birds and insects, the movements of shoals of fish or the trekking of herds of game and cattle in time of famine.

We may regard it as the voltage or driving force of life, a voltage which is continually rising and falling; it is an economic force which is insolubly bound up with the problem of the distribution of species.

I may say here, that this address is not an attempt to explain but to focus attention on the problem. The secondary curves, which I have mentioned, are in fact, merely oscillations of the scales of Nature.

We are accustomed to talk of the Balance of Nature, and our usual concept of that balance is that it is always on an even plane, but in these secondary oscillations, the balance seems to be upset. The truth is, that there is little or no equipoise in nature, its balance is continually being upset, its very nature is plastic to a degree. No race can hold its own for long, not excepting man himself. History abounds with the stories of the rise and fall of empires, and geology teaches us of the extinction of countless species, plant and animal life, vertebrate and invertebrate; each in its turn is weighted down and submerged by some more dominant creature.

The main curve, that is the steady rise and fall to extinction of a species, has been explained to the satisfaction of most of us, by the generally accepted doctrine of natural selection and the survival of the fittest, but, in the short time at my disposal, I have been able to find but few references in literature which attempt to throw light on the periodic oscillations in the life curve of a race.

Let us take some familiar examples illustrating this periodicity. Most of us here have heard of the familiar butterfly known as the Pale Clouded Yellow in England, a species of *Colias*, a genus well represented in India and by one species in this Presidency. The Pale Clouded Yellow makes its appearance in the counties of England fairly regularly every seven years. Looking up records, I find that it literally swarmed in the years 1821, 1828, 1835 and again in 1842. From these periodic visitations, many lepidopterists prophesied that there would be a like abundance in the year 1849, this prophecy was not fulfilled however and in fact, it was not until 1868, an odd year, that it again swarmed. Newman states that,—“The fitful and capricious appearance of this butterfly in England has led to many predictions and hypotheses respecting the periodicity of its visits but all attempts to systematize these visits have proved futile.” Be that as it may, we have here a very good example of the periodic ebb and flow of life, and one which has defied the efforts of all zoologists to elucidate.

Let us take another example familiar to botanists and one nearer home, showing that this periodicity is shared by plant as well as by animal-life, viz., that of the numerous species of *Strobilanthes*.

As most of us know, these plants bloom with a very regular periodicity and anyone who has had the good fortune to see the Nilgiris during one such period will easily comprehend how these Hills have got their name. Has any botanist attempted to explain the rhythmic periodicity of *Strobilanthes*? Botani-

cal books give me the years of blooming, but they do not venture on any hypothesis to explain the periodicity.

I have been told by sportsmen in the Nilgiris, that a strobilanthes year is followed by a good year for jungle fowl and this on account of the abundance of food afforded by the plant seeding. It is well to note this, as it would seem that, on occasions, the periodicity of one organism directly reacts on the periodicity of another. I am able to give an example of such which has come under my own notice, proving that such a reaction is often the case.

The early part of last year in Malabar saw great numbers of a common butterfly, *Delias eucharis* on the wing. As a result of this swarm, great numbers of larvae appeared later, feeding on *Loranthus*. Now this larva is greatly parasitized by a species of Tachinid, so that later on in the year, numbers of these flies made their appearance. Visiting the old cemetery at Palghat during September I noticed some of the tombs literally encrusted with the pupae of *D. eucharis*, but although I examined some scores, I failed to find a single one which had not been parasitized by this fly. I may observe that the butterfly was decidedly scarce during the latter part of the year. We see here, how the increase of one organism, the host, results directly in the increase of another, its parasite, and secondly that the increase in the numbers of the parasite reacts to a decrease in the numbers of the host. We can quite easily conceive how if the increase of the parasite were at all excessive, it would result in the total extinction of its host and thus of itself, for the one is dependent on the other. We may ask ourselves if such an accident ever occurs, and in fact, after noticing the great numbers of *eucharis* larvae parasitized, I asked myself this question. In seeking for an answer I discovered that from the majority of pupae attached to the tombstones, neither butterfly nor parasite had emerged. The explanation of this was, that nature had overdone her work, the larvae had been overparasitized, that is to say, the larvae had been attacked by several flies, with the result that the amount of food contained in the body of any one larva was insufficient for the large number of grubs devouring its tissues, all thus dying from starvation before reaching maturity. The balance of nature is exhibited here, but it is precarious in its fineness. One would say that nature was taking risks and no doubt these risks are very real, thus accounting for the extinction of many organisms. One occasionally observes these tragedies in actual nature; I remember one such at Vizagapatam. A flight of a species of Noctuid, which lasted for about four days, flooded the country adjacent to the coast with myriads of these insects, hundreds of which arose from every bush and tree one cared to shake. A vast swarm of larvae resulted from this invasion but the particular plants on which they fed were exhausted long before the larvae reached

maturity, so that I doubt if a single one survived. The whole country-side was alive with marching hordes of starving larvae vainly searching for food. Nature's balance was top-heavy and overweighted in this case, resulting in a wholesale destruction of insects.

I believe that among other factors influencing periodicity in the increase of animal life, the unequal distribution of species, which results in overcrowding and a comparative lack of food, plays a large part. I may best illustrate my meaning by the following example :—

During the month of October 1918, I was staying for some days in the Bombay Docks, on board of one of the transports, from the decks of which I witnessed the flight of countless myriads of several small species of lacustrine dragonflies. They swarmed on all the ships in dock and vast numbers could be observed skimming over the surface of the water in the docks. So vast were the numbers on board the ships that in places, as they rested on the beading of the roofs of deck houses, they resembled from a short distance, a coarse kind of grass, the projecting attenuated abdomen giving this appearance. As is usual when ships are laid up in dock, a good deal of painting was going on, and as the insects stuck to the fresh paint, deck houses began to resemble fly papers. There was a good deal of bad language employed by ships officers as a consequence, which however effected nothing in clearing the atmosphere from dragonflies. The swarm went on for several days, during which millions must have passed over. They appeared to be drifting in from the sea, but were, I fancy, merely following the coast line in a northerly direction.

Now from whence came this swarm and whither did it go ? That was the problem set me at the time and it took exactly ten years before I found the solution. Last year I was transferred to Malabar and during that period, was able to make some interesting observations about the local Odonate fauna. In the early part of the year I was particularly struck by the almost entire absence of those forms which breed in still waters such as tanks and lakes ; riverine forms on the contrary, were quite plentiful. The reason for this was soon evident, for I found that the whole of North Malabar is destitute of tanks and lakes in which lacustrine forms could breed. This part of the country depends almost entirely on wells for its water supplies but to a slight extent on river water. Later on in the year I toured South Malabar and found that it was the very antithesis of the northern parts, tanks abounding in every direction. Calicut for instance possesses only three or four tanks, whereas the Palghat Municipal area has well over one hundred. Here then, as would naturally be expected, I found an entirely different fauna, lacustrine forms abounding.

With the advent of the monsoon, many adventitious

tanks at once made their appearance in North Malabar, the paddy lands were soon flooded and local conditions began to approximate to those of the South. Lacustrine Odonates soon began to be in evidence, at first a few but rapidly increasing, thus proving that there was a steady movement northwards of the lacustrine forms of South Malabar. All specimens taken were comparatively old showing that they had not emerged locally. At Chevayur, four miles out of Calicut, one of the adventitious tanks referred to, made its appearance in a single night after heavy rain, and what had been a large dry depression the day before, was now a fine sheet of water resonant with the croaking of countless frogs. Two evenings later, when I visited it, I found it alive with a small species of dragonfly, one which I had never met with before, but which I subsequently found quite common in South Malabar, from whence it was evident the flight had come. Here then was a sudden access of amphibian and insect life, the former probably awakening from their aestivation, the latter, an overflow resulting from an unequal distribution in South Malabar. It was at this time that I began to suspect dimly from whence the Bombay flight had come, but definite proof was still wanting. It was clear that with the passing away of the monsoon and the drying up of the paddy lands and tanks, a vast horde of aquatic insects would be left without breeding grounds, and must perforce migrate or perish. This became more evident as the monsoon drew to a close. Teneral or newly emerged dragonflies began to make their appearance, evidencing that active breeding was going on locally in the paddy and in the multitude of small adventitious tanks. Even the smallest of the latter was swarming with all forms of aquatic insect life and the undergrowth of my own compound was literally teeming with newly emerged dragonflies belonging to the same species which had composed the flight seen in Bombay.

The monsoon last year ended rather early and abruptly in North Malabar and by the first week in October, it was already rather dry, most of the tanks had disappeared and the paddy lands were dry. Co-incident with this, the swarms mustering and feeding up in the undergrowth, quite abruptly disappeared, and by the 10th of October I was unable to find a single one of these species in my own compound.

Had the flight gone north or returned southwards? I think that there can be no doubt but that they went northward as South Malabar was already overcrowded and there would be no room for a fresh influx. Possibly the tide of insect life advances and retires to South Malabar and Cochin annually, but the bulk of it must advance in the direction of food supplies, that appears to me to be a natural law applicable to all organisms; the emigrant moves ever onwards be he man

or beast. I believe therefore that this ebb and flow of aquatic life on the West Coast is an annual affair and dictated by the unequal distribution of species and the struggle for existence. It has been theorized that the migrations of birds and insects is a relic of glacial invasion and retreat and follows ancestral routes; I am prepared to accept such a theory in the case of birds but I doubt if we are on such firm ground when dealing with insect life.

Howe commenting on the migration of dragonflies in New England, states that annual autumn and spring migrations have been observed but that the general trend is towards the south. He also states that the migrations are confined to the larger species of strong flight and opines that distributional extension must at times result from such flights. He gives the case of one species, a regular migrant, which has the widest distribution. We may well ask ourselves,—“Is the distribution of a species carried out by such intense emigrations, likely to be at all permanent?” On the face of it, it would seem that there can be only two interpretations of the utility of fighting in insects, one being the extension of the distribution of the species, the other to take advantage of a temporary provision of food supplies in adjoining areas, and yet, if the distribution is at all permanent, then why the necessity of annual or, at least, periodic invasions? Here we open up a wide field for investigation by Indian students, for this great continent of India offers unrivalled opportunities for such studies. To those interested in this branch of zoology I would commend Mr. E. B. Williamson's series of papers on the ebb and flow of life in the Vanemon Swamp of Bluffton, Indiana States, wherein he shows a startling series of comings and goings of various species, not only of animal but also of plant life. He has carried out annual investigations and observations on this swamp for the past twenty years or more and a fascinating story of the genesis and exodus of many species is unfolded. The swamp may be choked with an aquatic pest like our water hyacinth for some years, yet this may utterly disappear without explainable reason; a species of dragonfly has been noted for some years and then disappears for a decade, to again reappear after that period of time. Various species seem to dominate the swamp in turn; it is a miniature portrayal of the universe depicting the rise and fall of kingdoms, and goes to prove that colonization brought about by the agency of mass immigration, although lasting for a time, is never permanent.

Commenting on the association of species in the Vanemon Swamp, Mr. Williamson says:—“But this association is no fixed thing, it is a fluctuating association marked by comings and goings, by appearances and disappearances, by ebbs and flows. *Libellula quadrimaculata* was there for only one year;

Enallagmas appeared in 1907, to disappear until 13 years later; certain species are present every year. Formerly a Sparganium swamp, the Sparganium has entirely disappeared; a Scirpus (Bullrush) came in, spread for a few years and has gone; and so it goes on."

Mr. Howe, in the paper previously referred to, states that migrations are confined to the larger species with strong flight, but I think that he will find few to agree with these views. My own observations have been rather to the contrary, although made on the same group of insects as Mr. Howe's. It is the smaller species which appear to have developed the habit most strongly and their light build enables them to spread over incredible distances by taking advantage of air currents and trade winds. The tiny little *Agriocnemis* has thus spread from India to the Pacific Isles; *Ischnura senegalensis*, another small dragonfly, is to be found from the West Coast of Africa to the Philippines, and although essentially an insect of littoral areas, has established a thriving colony on the lake at Ootacamund at an altitude of 7,250 ft. *Enallagma cyathigerum*, a similar type of insect, has actually succeeded in completing the circumference of the world and is equally common in England, Kashmir, and North America! In following up this ebb and flow of life we come on some most enthralling and puzzling problems in distribution. To take some examples from the same order of insects, which we meet with in India,—*Sympetrum fonscolombei*, a medium sized dragonfly common in Europe and quite occasionally taken in Great Britain, has established thriving colonies at Ooty and Kodai-Kanal, although it is unknown from the rest of India. The nearest point from which it has been recorded is not less than 1500 miles from the Nilgiris! There are two species of *Odonata* representing two Australian genera found in India and we have to ask ourselves how these two insects crossed Wallace's line and reached the sheltering hills of Hindustan. One of them breeds in lakes, montane or sub-montane in nature, so that its chances of finding a suitable locality to colonize were decidedly limited; yet it has been entirely successful in spite of this handicap. Life flows strongly and clings tenaciously to a suitable environment, as this particular instance serves to prove. *Hemicordulia asiatica*, the insect referred to, was first located in Shillong as far back as 1878 and rediscovered again in the same locality by Mr. Bainbrigge Fletcher in 1918. An emigrant from Australia, we know that it has established itself in Assam for at least 40 years. Since that date Mr. Bainbrigge Fletcher has discovered the same insect breeding in the lake at Kodai-Kanal and I myself on the lakes at Lovedale, Ooty and Coonoor in the Nilgiris and in one small tank in Coorg. Now all these pieces of water are artificial and of comparatively recent formation, so that any fauna found in their waters is of modern colonization,

indeed we may put their age as a little under that of the date of the construction of the Ooty lake. This being so, I think we are on safe ground in surmising that this little emigrant from the antipodes has reached the Nilgiris and Palnis via Assam, the nearest point as the crow flies being 1,400 miles. It has not been reported from any locality between these two areas and I know of no suitable place where it could find shelter.

There is some evidence to show that if an organism establishes itself at the outset in considerable numbers in a locality, where it is unopposed to any opposition, its fecundity will become so abnormal as to be able to resist the immigration of other species of its own genus or even order. There are striking illustrations of this in the Nilgiris, in the lakes which I have already mentioned. These being purely artificial and of recent origin, it is obvious that at their inception, they must have been devoid of aquatic insect life, or at the most, peopled only by a few forms fed to it by the streams which filled their basins. Such forms would probably soon die out as they would be plunged into an unsuitable environment, riverine forms rarely taking kindly to still waters. If colonization had been gradual, we should expect to find a number of species still flourishing in their waters, one or two dominant, the rest struggling for existence, and scanty in numbers. What are the true facts as observed by myself? In the Ootacamund lake I found *senegalensis*, which I have already mentioned, swarming in vast numbers and the sole representative of its class or family of *Odonata*. On the Lovedale lake, about one mile away as the crow flies, but separated by a lofty ridge, I found an entirely different species, *Aciagrion hisopa*, in almost equal numbers, and like *senegalensis*, the sole representative there of its family, to which *senegalensis* belongs. One would have thought that a species like the latter, which had spread from West Africa to the Nilgiris, would have been dominant enough to oust *hisopa*; that it has not done so can only be explained by *hisopa* having already established itself in such numbers as to resist the invasion of *senegalensis*. I do not know the ages of these two pieces of water but as *hisopa* breeds freely on the Kundas and *senegalensis* is not found there, I conjecture that Lovedale is the older. This is supported by the fact that *hisopa* is found holding undisputed sway on the pond in Sims Park, Coonoor.

Now I perceive that this address is rapidly deteriorating into a discussion on the distribution of *Odonata*, but it was inevitable that I should draw on this order, with which I am most familiar, for examples to illustrate the various points raised. Life, however, flows on very parallel lines and equally apt illustrations might be drawn from any other order. Let me mention one or two of such.

Here in Southern India and Ceylon we are accustomed to

see an annual and seasonal increase in the *Catopsilia* butterflies. In Colombo, at the end of the S.-W. monsoon, myriads of these insects may be seen fighting in one direction like driven snow. So well known is the phenomenon that the Singhalese allude to it as the "pilgrimage."

Where these insects come from and where they go to, has never yet been satisfactorily explained. They are usually accompanied by other species of butterflies such as the *Euploeas*.

In the order Coleoptera I have seen vast swarms of *Cantharides* beetles trekking across country near Poona. They formed an enormous belt moving forward like a Zulu impi, and the noise of their buzzing wings could be heard from a long distance off. We know practically nothing of the origin of these swarms.

Take another order, the *Rhynchota* to which belongs the well known water bug *Belostoma indica*. I was once involved in a most unpleasant flight of these cumbersome and unpleasant creatures. They started coming to light about eight o'clock in the evening and swept into the verandahs and rooms of my bungalow, crashing against the walls like shots from a machine gun, the sonorous buzz of their wings heralding their approach. Hundreds of the creatures poured in and so fierce was the bombardment for the best part of one hour that we were driven indoors. This flight came in directly from the Bay of Bengal and we are left to conjecture as to whether it left the coast at some point above or below Waltair, or had effected a passage across the Bay!

Lastly I may mention the oldest records of periodic increase in certain organisms,— that of the plagues of Egypt, of which we are continually reminded by the scourge of locusts nowadays.

There are a number of other factors involved in the ebb and flow of life. Climatic changes, for instance, play a large part in propagating or destroying life. Seasonable seasons result in an increase of insect life, whereas an unseasonable season, by upsetting the normal cycle of life, the dates of emergence of pupae, etc., results in what the collector calls a poor season. The emergence of insects is profoundly affected by the onset of the monsoons. Thus the average entomologist can usually tell you more about the monsoon, and when to expect its break, than the whole of the staff of the meteorological department, indeed I think members of that department would be a little more accurate in their pronouncements, if they were compelled to take out a course in entomology or zoology.

Cyclonic disturbances are frequently heralded by fighting of insects and undoubtedly play an important part in the wide distribution of species. Caught up in the vortex, they are

carried to enormous distances. I have seen a ship coated with insects, principally Hawk moths, which had been swept off the Kathiawar coast by a cyclone. I published a list of the insects which were found on board, all in good condition although the ship was at least 40 miles off the coast. Probably such swarms ultimately turn and make for the coast again, otherwise incalculable numbers would be swept out to sea to perish. It is interesting to note, however, that a comparison of the Indian and African faunas furnishes strong evidence that some of our species have succeeded in crossing the Indian ocean!

Distribution has gone on amongst mammals at a much slower pace than amongst birds or those insects gifted with the power of flight; mammals could never hope to traverse the barriers which these surmount. Yet we commonly find insects, which although gifted with considerable powers of flight, are strictly confined to quite small areas. What factors control the distribution of such species? Are they trapped by the entire suitability of their environment or are they bound to the spot by insuperable geographical barriers? Doubtless a combination of these factors is the real explanation. Dr. J. C. Willis, the botanist, whose chief work was carried out in Ceylon, and to whose "Rule of Age and Areas" I believe few of us subscribe to, admits this when he states that, "the area occupied by any group of allied species may be enormously modified by the presence of barriers such as seas, rivers, mountains, changes of climate or other ecological boundaries and the like".

Now in India we have unrivalled opportunities for studying the action of barriers such as I have mentioned, for there is probably no country in the world which, for its size and compactness, possesses so many diverse climates and geographical features. It has deserts almost as arid as the Sahara, with a rainfall of less than ten inches a year, and it has wet areas whose rainfall is unequalled by any place in the world; its temperatures range from far below freezing point, as in the eternal snows of the Himalayas, to well over 100 degrees in the shade, as in the eternal heat of Madras; it has fine rivers, spacious lakes and broad plains and plateaus which alternate with extensive ranges of mountains clothed with magnificent jungles, and finally, its altitudes range from sea-level to the highest in the world. With such a variety of geographical and physical features we must expect to find many natural barriers which serve to limit or extend the distribution of species.

As two of such I may mention two very interesting examples, neither of which has received its due attention from zoologists or botanists. I allude to the Palghat Gap in the Western Ghats and the vast plain of the Ganges, which latter serves to separate the Himalayan fauna from that of Peninsular India. Each of these two barriers is a Wallace's line in

miniature and if we confine ourselves to a study of the endemic faunas of the hilly tracts on either side of these gaps, we shall come to some very interesting conclusions. I think it essential that we should restrict our studies to endemic species, because non-endemic ones do not appear to be restricted by ecological boundaries as are the endemic species, and their inclusion is more than likely to make us arrive at wrong conclusions. I think that I am correct in saying that many non-endemic species found in montane areas are those which are found commonly flourishing in the plains, and to these, barriers like the Palghat Gap and the Gangetic Plains offer no restrictions of dispersal. The truth is, that the average species of the plains and the sea-levels has a greater adaptability than the montane or submontane ones.

I have had neither time nor leisure to contrast the flora and fauna of the areas which inhabit the walls bordering these two gaps, but such little study as I have been able to give to the subject, especially in regard to *Odonata* and *Lepidoptera*, has shown a sharp division into definite faunal areas pointing significantly to the effectiveness of the two barriers.

In the case of the Palghat Gap, to which I have given more attention, I find the fauna to its south has a definite Ceylon facies pointing to some past connection of the Cochin and Travancore Hills with those of Ceylon. Now this gap in the mountains is very narrow, and at first sight, it hardly seems possible that so short a distance as some 40 miles, could control the passage of organisms gifted with flight, from one area to the next. I believe the reason to be that it is the very narrowness that gives the barrier its real strength, for the current of air continually sweeping through it forms tremendous eddies which sweep any organism attempting to cross it, back to its own shores again. The comparison of the air-currents through the Palghat Gap and the Straits of Mannar is like comparing the current of a mountain torrent pouring through a confined gorge, to the placid flow of a river when it has emerged into its estuary. No one can cross the former without the danger of being swept to destruction; the passage of the other is fraught with no dangers, and so it may be in the case of winged insects attempting to stem the swift current of the Palghat Gap.

Now I have mentioned purposely a number of problems, all of which, if they are to be solved, must be solved by workers in the field. From a survey of the papers presented for reading at this meeting, I have gained the impression that there is a tendency to follow rather slavishly the methods of research adopted in Europe and, to a less extent, in America. New fashions of study are continually cropping up in all the sciences, zoology not being excepted, but there is no reason why you should be slaves to fashion, indeed from the advantages offered

to you here in India, there is every reason why you should strike out on a definite line of your own, your work being devoted to a study of those problems of nature whose solutions are to be found only on the spot.

Problems such as I have merely touched upon can never be solved at the bench in the laboratory but by hard keen practical research in the field. Unless a student has a good knowledge of classification and natural history, which latter some affect to despise, he will never make a good zoologist, for these two form the grounding which later will orientate him for more special studies; practically all the fathers of zoology and botany exhibited a love of natural history from their earliest youth.

You will find in most English schools a few scholars who take up the study of natural history as a hobby from an innate tendency to study nature for the love of nature. I do not find the same tendency in the Indian scholar and I have never yet met a single medical student in this country who exhibited the slightest interest in natural history. I am told that such studies do not advance one in the profession of medicine or that no time can be spared from ordinary studies, and again by others, that you cannot study nature without destroying life, meaning I suppose, the collecting of butterflies and other forms of life.

Few of these excuses ring true and as for the lack of time, I believe that we can all find leisure to devote to a little research outside our own narrow confines, and that such time is well spent.

Another handicap which cramps the study of zoology in this country is the lack of suitable media in which to publish stray notes. With the exception of the Bombay Natural History Journal, there is no magazine which publishes miscellaneous notes on natural history, thus a mass of interesting information must go begging every year. In European and American cities numberless journals cater for the local natural history enthusiasts, so that from year to year we find published interesting details of the arrival and departure of birds, of the discovery of insects in new localities, of some curious instance of mimicry, of the nesting habits of some bird, of albinism occurring in some animal, and many other interesting and useful facts. Individually such items may seem trivial but they all help to swell the fountain of knowledge and will undoubtedly help future workers to solve problems which baffle the present generation. I would like therefore to see every college running its own field club and to see a few pages of the college journals devoted to notes on natural history.

To the Indian student of zoology I would say that the begin-all and end-all is not to be found solely in the laboratory. Theories manufactured in the latter are apt to be fallacious when dealing with subjects which could be better studied in the

field. Let me give a concrete example,—The “Leaf Butterfly” or *Kallima* is invariably shown in all museums mounted on a twig and posing as a dead leaf. Even the British Museum has fallen into this error. The laboratory worker noticing the close resemblance of the shape of the wings of this butterfly and of the colouring of the undersides to that of a dead leaf, comes to a fallacious conclusion that the butterfly, when alarmed, immediately settles on a twig and assumes the role of a dead leaf. Specimens of the insect are thus mounted and exhibited to the public as examples of protective mimicry. A little reflection ought to show us that it would be difficult for the insect, when suddenly alarmed, to find at a moment’s notice a suitable twig and shape of leaf in which to merge itself. As a matter of fact the truth is stranger than the laboratory worker’s fiction. I have studied *Kallima* in the Nilgiris, and find, that when alarmed, it darts into the jungle, closes its wings and drops to the ground, at the same time falling over on to its side, and in such a position, looks exactly like a dead leaf. It matters not whether the leaves around match it or not, for in the average jungle you will invariably find an odd lot of foliage decaying on the ground. I may say that this habit is not confined to *Kallima* alone so that there is less excuse for the perpetuation of the fraud. Incidentally I may mention that I have frequently noticed *Kallima* fly to, and settle on the trunk of a tree when alarmed, in which position its colouring merged with the colouring of the bark. A similar habit is indulged in by the *Vanessidae*.

This great land of India is peculiarly adapted to the study of natural history in the field, thus an Indian School of Zoology could be made very distinctive and individualistic, characterized by its wrestling with the great problems of nature such as the distribution of species, environment, parallel and convergent evolution, mimicry as observed in actual life, the psychology of the jungle and a hundred other like problems. Already one sees a tendency towards such a school, the foundations of which were laid by distinguished members of the Zoological Survey of India. It is for the younger generation of Indian Zoologists to build and fashion the stately edifice, and to all these ardent young men I would say,—“There is nothing hidden which shall not be found out,” an ancient truth which should be the inspiration of all research workers.

Section of Zoology.

Abstracts.

1. Notes on the anatomy of *Pentaceros* (a starfish from the Indian Ocean).

J. DAYAL, Lucknow

The English text books describe the starfish *Asterias*, and until lately the practice was to obtain specimens from abroad and give them to students for dissection. Now we get a plentiful supply of starfish (*Pentaceros*) from Ennur which is dissected nowadays by the students of Zoology. The present paper gives an account of the anatomy of *Pentaceros*.

Sladen in his monograph on Asteroidea divides the class Asteroidea into two orders—the Phanerozonia and the Cryptozonia.

Pentaceros belongs to Phanerozonia—(Family Pentacerotidae). It possesses a relatively large disc and short arms, which taper gradually towards their extremities. The oral surface is flat and covered over with a number of minute rounded granules or tubercles, which on the ambulacral ossicles assume the form of short, blunt spines. Well-developed marginal plates are present, and the adambulacral ossicles take a prominent place in the circumoral ring of ossicles.

Abactinal surface is strongly convex and the skeleton is reticulate and regular, with more or less definite intermediate triangular pore areas. The ossicles on the aboral side are with prominent mammillated tubercles and the rays are carinated.

The pedicellariae of *Pentaceros* are all sessile and are of forciform, valvate and alveolate types.

Prominent interradial septa are also present.

The alimentary canal possesses five radial pouches of the stomach, ten radial hepatic caeca and five bifid rectal caeca placed interradially and on each side of the interradial septum. Each rectal caecum is beset with a large number of pouches. The anus lies in the centre of the disc on the aboral side.

The water vascular system in its general features resembles that of *Asterias* but differs from it in the possession of four polian vesicles placed interradially, and only one row of tube feet on each side of the ambulacral groove, but the ampullae are in two rows, an upper and a lower, and each tube-foot has two ampullae connected with it, one of the upper row and one of the lower row.

A detailed account of the external morphology, skeleton and the various organs is given in the paper.

2. Notes on the blood vascular system of *Hemidactylus flaviridis* Rüppel (the wall lizard).

M. L. BHATIA and J. DAYAL, Lucknow.

Three arterial trunks arise from the ventricle, and become right and left Systemic and Pulmonary. The systemic arches cross each other at their origin, so that the one arising from the right becomes the left and the other one from the left becomes the right.

The innominate arising from the right systemic is very small and soon divides into the right and left carotids, which run outwards and bifurcate into internal and external carotids. At the place of bifurcation

is seen a very prominent carotid gland. The ducts carotici which is a connection joining the carotids and systemic arches also takes its origin at the place where carotid gland is situated.

The presence of laryngeal artery (Laryngeal tracheal O'Donoghue) arising from the Pulmonary arch is an interesting feature. It passes up along the sides of trachea, to which it sends small twigs finally breaking up in the larynx.

All the main branches supplying the different parts of the alimentary canal arise separately from the dorsal Aorta. On the whole it shows great resemblance to *Sphenodon*, which is considered a Primitive type.

The Venous system shows big sinuses in the anterior region. Both the Hepatic and Renal Portal systems are well developed. A detailed account of the venous and the arterial systems is also given.

3. Effects of temperature and moisture on cocoon laying in the common Indian leech, *Hirudinaria granulosa*.

M. L. BHATIA, Lucknow.

About 30 adult leeches were kept in a glass jar in the beginning of April and allowed to copulate. Those which had copulated were separated and each one was kept under observation in an earthen pot with some moist lumps of black clay. Each pot was numbered and placed in a bowl of water in order to keep the clay inside the vessel wet. A piece of muslin was tied round the mouth of the pot, and water in the bowl was renewed every day.

Cocoon laying in Lucknow commences by the middle of April and lasts for about a month and a half.

Renewal of water in the bowl and daily temperature were noted. It has been observed that cocoon laying can be induced by adverse conditions i.e., by tendency to dryness and rise of temperature.

A detailed account and graphs showing the rise of temperature and reduction of water along with formation of cocoons is given in the paper.

4. Notes on the life-history of *Ora picta*; (Fam. Dascillidae-Coleoptera).

Y. RAMACHANDRA RAO, Coimbatore.

The paper records observations made by the writer on the habits and life-history of a small Dascillid beetle found by him present in large numbers in paddy fields at Palghat in August, 1923.

The larva was found to be thoroughly fitted for an aquatic life by being possessed of paddle-shaped legs and a flattened body. Respiration was found to be effected by the larva periodically rising to the surface of the water and carrying bubbles of air at the hind end of its body. The antennae were noted to be remarkably long. The grubs were found to emerge from water and to pupate on stems of paddy or grasses. The pupal period was found to be remarkably short, being only 26 to 28 hours. The grubs were found by the nature of their mouth parts unfitted for damaging plant tissues and are believed to feed on minute organisms such as Ciliate Protozoa and algae, present in water in the paddy fields.

5. Preliminary observations on the internal structure of the heart in certain Indian teleosts.

B. K. DAS and S. ANAND RAO, Calcutta.

Generally speaking, the heart in teleostean fishes is situated far forward, and is posterior and ventral to the last pair of gill clefts.

It is enclosed by the pericardium which is, as a rule, very thin and transparent, but in *Sciaenoides pama* it is quite thick and opaque. The sinus venosus is a thin-walled venous chamber, receiving the two ducti cuvieri formed by the union of the anterior and posterior cardinal veins, a single jugular vein (very often) and the hepatic veins, usually one or two as the case might be. A single median hepatic vein is observed in *Callichrous pabda*, *Plotosus canius*, *Wallago attu*, *Ophiocephalus marulius*, and *O. gachua*; but there are two hepatic veins in *Labeo rohita*, *Clarias magur*, *Saccobranchius fossilis* and *Ophiocephalus punctatus*.

The sinu-atrial aperture is guarded typically by a pair of distinct large semi-lunar valves, which in certain Siluroids, such as *Plotosus canius* and *Rita rita* (as well as in the America Cat-fish, *Amiurus catus* described by McKenzie) become united together to form one continuous valve, looped round itself serving like a diaphragm, and extending forward to be attached near the *ostium atro-ventriculare*. There is an internal depression (*Ophiocephalus marulius*) or an external dilatation (*Wallago attu*) marking the position where the ductus cuvieri enters the sinus venosus. The atrium is a more or less flattened chamber, and its inner wall is beset with a large number of trabeculae carnae which run in various directions thus dividing the atrial cavity into several smaller spaces. It communicates with the ventricle by means of an aperture guarded by semi-lunar pocket valves, which show considerable variations as to their size and number, and present many interesting modifications in 23 species of fish investigated.

In a few cases the difference in number and relative size of the valves in the same species depends largely upon the age and size of the particular fish, such as in certain Carps, viz., *Labeo rohita* and *Calla calla*. Remarkable thickness and opacity characterise the valves of *Plotosus*. In *Rita buehanani* there is a small additional pocket-valve lying along, the passage leading from the ventricular cavity towards the abortive Conus arteriosus. Curiously enough, in *Hilsa ilisha* the cavity of the ventricle is almost obliterated due to the extensive thickening of muscular walls as well as trabeculae formations, but the two valves of the conus present thick oval hemispherical "cups" towards their bases, which on coming together enclose a small recess, thus providing for temporary lodgement of blood during its forward movement. Furthermore, it is interesting to note that certain primitive Malacopterygian species, *Megalops cyprinoides*, like *Albula*, possesses two rows of pocket-valves is the conus and four atrio-ventricular valves, but Senior states that he discovered only three of the latter series in the same species of fish examined by him; and yet in another Acanthopterygian fish, *Datniodes quadrifasciatus* there are three conus valves, i.e., one more than the normal number of valves present inside the conus.

6. On a peculiar type of branchiae in an Indian symbranchoid 'Eel', *Amphipnous cuckia* Ham. Buch.

B. K. Dass, Calcutta.

Curiously enough, the gills of *Amphipnous* ("Cuckia Eel" of India) are not of the biserial type as in a typical teleostean gill, i.e., they are not arranged in the same plan as in a holobranch. They are simply long, flexible, filamentous, highly vascular structures present along the mid-region of the outer surface of the gill-plate borne on the ceratobranchial segment of the second gill arch; the other arch being devoid of any gills in the adult. The gill filaments are slightly flattened and semi-transparent, and the capillary network can be easily made out with the aid of a hand lens; most of them are either bifid or trifid towards their distal ends, and in some the furrow dividing the lobes of the filament may extend considerably high up towards their bases; there is no cartilaginous or bony support for the gill filament as in a normal gill.

The fish habitually spends most of its life out of water in muddy banks, and this continued habit in the mud has led to certain most remarkable *adaptive modifications* in the anatomy of this unique fish, such as the development of an efficient accessory air-breathing organ or the so-called "lung" and the extreme reduction of the branchiae. During post-larval history the gills are at first suppressed for a time, although *five* gill arches are present from the very start, but before any gills have made their appearance the newly acquired "lung" is the only organ that plays the most important rôle in the respiratory exchange.

Rudimentary gills, however, gradually begin to *bud out* over the three branchial plates sometime *after* the so-called "lung" is fully functional, and then undergo a curious *retrogressive metamorphosis* during which the gills are lost over two of the arches, persisting throughout life on the second branchial arch alone, just as the fish changes from an aquatic to a semi-terrestrial mode of life. The vascular supply of these gills is also quite peculiar.

The gills in *Amphipnous* have thus undergone an almost complete degeneration and are of little value so far as the respiration of the fish is concerned, and are evidently widely different from those of the other two members of the same sub-order Symbranchii, *viz.*, *Monopterus* and *Symbranchus* which however, possess no accessory air-breathing organ.

7. On some salient points in the arterial system of a Bengal agamid, *Calotes versicolor* Daud.

B. K. DASS and B. K. MITTER, Calcutta:

(1) The Carotid arches arise together by means of a common *Carotis-primaria* from the right Systemic arch. This mode of origin of the Carotid arches varies in several Lacertilians.

(2) The internal Carotid artery has a much wider range of distribution amongst the Reptiles as compared with a similar vessel in the Amphibians.

(3) A functional, very highly developed *Ductus Caroticus*, the remnant of the anterior part of the supra-branchial artery, is present in either side as in *Sphenodon*, and, therefore, retains the primitive feature, a fact displaying great physiological potentialities. It gives off a well-marked Cervico-muscular artery. The position of *Ductus Caroticus* in other Reptiles has been discussed. There is no *Ductus (arteriosus) Botalli*.

(4) There are two separate Systemic arches that unite to form the Dorsal aorta. The left one is entire, whilst the right one (*Systemico-carotid trunk*) gives off the common carotis primaria, the vertebral artery, two stout subclavians and a pair of parietal arteries. The subclavians show some differences in their origin amongst the Lacertilians, and, besides other branches, they give off the anterior Epigastric arteries.

(5) The Pulmonary arches (*i.e.*, the 6th of the embryonic series) are two in number, and are united together at their proximal ends into a common trunk. Each arch gives off an interesting vessel known as the *Laryngeal artery*, which is the homologue of the Oesophageal artery of the Urodele, and quite as much prominent as in *Sphenodon*, another primitive feature.

(6) The Dorsal aorta gives off 14 pairs of segmentally arranged parietal arteries, one pair of oesophageal arteries, one pair of mid-gastric (coeliac) and single mesenteric arteries, one pair of genital (receiving the oviducal arteries in the ♀) and 5 pairs of renal arteries, and two lateral common iliaes as well as the median and terminal caudal artery.

(7) The arterial system of the present species thus retains many *primitive features*, and shows its relationship with that of *Sphenodon* and Urodeles. It has also been compared with other common Indian Lacerti-

lians, such as *Varanus bengalensis*, *Hemidactylus flaviviridis* and *Uromastix hardwickii*.

8. The occurrence of *Kittacincla macroura indica* Stuart-Baker in the district of Ranchi.

S. C. LAW, Calcutta.

The only available record relating to the avifauna of Ranchi is that of V. Ball in the Stray Feathers, Vol. II, p. 412. The latter mentions the Shama—*Cercotrichas macrourus*, Gm.—as “extremely rare in Chota Nagpur” and cites only one instance of his meeting with it in Lohardugga, which formerly denoted a great part of the area now falling under the district of Ranchi. My tour in the district during October-November, 1927 afforded me opportunities of coming across not only isolated specimens of *Kittacincla macroura indica* Stuart-Baker, but also some typical haunts of this bird. The present paper embodies full details as to these haunts and the localities where they have been found by me. Below is quoted from my diary one instance illustrative of this :—

“1927, October-November: Hill-jungles off Rajadera (Ranchi-Purulia Road), beyond Angara, with buttress ranges clad with tree-forests: configuration rugged, well-watered, broken up by ravines and a stream which debouches into the foot of the range; creeper-twined thickets and bamboo-scrub line for some distance either side, and sometimes the course, of the hill-stream; glades, narrow valleys and patches of cultivation around an isolated hut in the clearings amidst wilderness are other features of the locality. Each of these features appears to be associated with the bird's movements in different hours of the day. In early October mornings I notice it in the glades among bamboo-growth beside the gurgling stream. When the sun is fairly hot, it retires into the shade of the forests. Its piercing song from afar furnishes a clue as to its presence in one of the higher hills and guided by it, as one ascends and draws nearer, its *chat, chat* voice, repeated in the intervals of its song, discloses its identity amidst the underwood of a shady valley. The ravines, deep and long-drawn, and often beset with creeper-twined thickets are favourite resorts for the afternoon, while at dusk they cling to the water-side, moving about on the boulders along the rock-strewn bed of the stream. A dip in its water terminates the bird's activities for the day. It retires to its roost, and in the trail of gathering gloom, which blights all view of the roosting Shama, gushes forth a stream of melody which still bespeaks its presence within the forest.”

My observations on the distribution of this bird are summed up as follows :—

Not unfrequent in certain congenial haunts, lying mostly in the fringe areas of the district. Avoids generally the bare rolling uplands, and affects wilder tracts broken up by rock and jungle. Pre-eminently a forest bird, haunting *Sal* and other timber forests (protected or otherwise), girdled or cut up by mountain-streams, which debouch into the foothills; straying not infrequently into the latter by reason of its fondness for the water-side. Very partial to patches of bamboo-growth in this area, to which it clings tenaciously, though occasionally rambling to to the valleys and glades, and even the highways which sometimes traverse these hill-tracts.

9. Notes on certain cytoplasmic inclusions in the oogenesis of *Zamenis mucosus* ('*Ptyas mucosus* O.' Nicholson).

D. R. BHATTACHARYA and K. B. LAL, Allahabad.

The Golgi bodies in a well formed egg become peripherally arranged where they appear as a dense layer. All sizes, from minute grains to

fairly large spherical bodies can be distinguished. At this stage the medullary region is markedly free from Golgi elements. In earlier stages Golgi bodies appear to give rise to fatty yolk, and this process of yolk formation is confined to the medullary region. The mitochondria are at first granular but in later stages become distinctly spherical and even swell up and attain nearly the same size as those of true yolk bodies. They are distributed throughout the cytoplasm in the usual way. True yolk bodies develop inside a vesicle and appear to be cytoplasmic in origin. There is distinct evidence regarding the infiltration of Golgi bodies from the follicular epithelium to the egg.

10. On the gastropod molluscs of the Indawgyi lake, Burma.

H. SRINIVASA RAO, Calcutta.

The present note is based on a collection of gastropods made by Dr. B. N. Chopra from the lake and the adjacent country in the year 1926. A short account of the physical features of the lake is given, and the species recorded are enumerated with reference to their habitat. 21 species including a few forms and races belonging to 14 genera in 7 families are known from the Indawgyi valley. 5 species and one form were hitherto undescribed. The gastropod fauna of the valley includes several species common to India and Burma. The geographical distribution of the genera and species is briefly discussed with special reference to the gastropod fauna of the Inle valley in the Southern Shan States and the Manipur valley in Assam.

11. A preliminary note on the metachromatic bodies in *Paramoecium caudatum*.

EKENDRANATH GHOSH, Calcutta.

The metachromatic corpuscles extensively studied in plants have also been described in several rhizopods, many flagellates, few coccidia and a ciliate (*Opalina*). The present paper embodies the study of metachromatic bodies in *Paramoecium*. The metachromatic bodies stain vitally with a large number of vital stains (fully enumerated by MEYER and GUILLIERMOWD) of which Methylene blue, Nile blue, Cresyl blue, Neutral red and Safranin have been applied successfully in the present case. The important characteristic noted by MEYER, viz., the blue staining of the metachromatic bodies by Methylene blue is not decolorized by subsequent treatment with one per cent. sulphuric acid solution (unlike the nuclear staining), is found to apply well here. The metachromatic bodies of *Paramoecium caudatum* are spherical to broadly oval bodies, embedded in the cytoplasmic substance, frequently at the point of junctions of several alveoli, which are of varying shapes and sizes. As examined in sections, 2-4 microns in thickness, the bodies do not seem to lie in alveoli. Examined fresh they do not show any Brownian movement. The metachromatic bodies vary from less than one micron to more than two microns in size.

12. On the cytoplasmic inclusions of *Unio* during oogenesis.

C. B. MATHUR, Allahabad.

The Golgi apparatus in the earliest stage is juxtanuclear and excentric. With the development of the ovum it breaks up, spreads out into the general cytoplasm, and appears to multiply, probably by division. Later on they swell up and hypertrophy, the interior becoming fat-like in nature. The Golgi bodies appear to be always spherical in shape.

The mitochondria in very young oocytes are restricted to a special

zone near the nucleus and are probably filamentary. Later, they disperse in the cytoplasm and appear as granular bodies. In older ova they surround the proteid yolk and seem to influence their composition in some way or other.

There are three kinds of deutoplasmic inclusions in the fully developed ovum of *Unio*, (a) fatty-yolk, (b) proteid yolk, (c) fat.

The nucleolar extrusions appear very early in the history of the oogenesis of the ovum. The formation of proteid yolk and fatty yolk is influenced by both the nucleolar extrusions and the mitochondria.

13. On a new larval Trematode of the Agilis group—*Cercaria indicæ* XLV—with an account of the encysted stage and notes on the life-history.

H. R. MEHRA, R. C. CHATTERJEE and ABDUL JABBAR FARUQI, Allahabad.

Observations were mainly made during the months of August and September, and of about 200 specimens of *Planorbis exustus* opened more than two thirds were infected with this cercaria. The larval forms nearly resemble *Cercariae indicæ* XLI of the agilis group described by Sewell, but the differences are prominent enough to place them under a new species.

The cercariae, when found in large numbers, are almost always associated with rediae. The rediae are larger in size than those of *C. agilis* Filippi and of *C. indicæ* XLI Sewell, but the size of the gut is relatively smaller and the position of the locomotor processes further back. The cercariae differ in the presence of a well developed intestine which bifurcates in front of the acetabulum; the caeca reach near the hinder region of the excretory bladder. They differ also in the structure of the ovary which consists of six large cells arranged in 3 transverse rows and in the absence of the testis. The excretory system of cercaria is described in detail. The flame cells hitherto unobserved in the agilis group are nine in number on each side. The structure of the rediae, cercaria and cyst is described.

A large number of cysts were also found in the snail which was infected with cercariae. In a number of snails, however, only cysts were present but no cercariae. The cysts are generally found attached to the mantle and contain a circular row of prominent collar spines 27-28 in number around the oral sucker. De Filippi's statement that *C. agilis* does not develop collar-spines until it enters on its encysted stage is thus confirmed.

The cysts of the species have been fed to young ducklings and it is expected that they will develop into the common *Echinostomum* found in the gut of the domestic duck.

14. Notes on the life-history of a Stylet cercaria (*Xiphidocercaria*)—*Cercariae indicæ* XVII, Sewell.

H. R. MEHRA and R. C. CHATTERJEE, Allahabad.

Certain stages in the life-history of the Stylet cercariae found in *Planorbis exustus* were studied along with those of *Cercaria indicæ* XLV already described. The Stylet cercariae are less abundant than the latter and hitherto we have not been able to find both the cercariae in the same snail. In most of the snails, however, we have been able to observe the cysts of both of these cercariae lying side by side in the mantle. This species is obviously *Cercariae indicæ* XVII described by Sewell.

Large number of cysts at various stages of development were studied and young trematodes obtained from mature cysts by breaking the cyst walls. The Stylet is present within the oral sucker in the young cyst;

but later on it is shed when it is seen lying on the surface of the cyst wall of the large cyst. The position, shape and size of the young Trematode as contained in the cyst were studied throughout the development. In young embryos the bladder is first somewhat Y-shaped, later it becomes almost spherical, then elongated and tubular and finally S-shaped.

In the mature cyst the young trematode shows wriggling movements and has developed fairly prominent spines on its body wall; its body also becomes somewhat folded owing to movements. The genital organs though immature are present when the trematode comes out of the cyst.

Feeding experiments to detect its adult condition are being performed.

15. The Golgi bodies of free living Protozoa.

H. S. MADHAVA RAO, Bangalore.

The Golgi bodies have been studied in free living protozoa isolated from soil and activated sludge. The nature of these bodies has been discussed. They are found to occur at first as simple granules which becomes rod-like, these rods then unite to form a network, and finally the networks anastomose to form definite bodies.

16. Geophilids from the bed of the river Cooum (Madras).

BONAVIS BONNELL, Madras.

Generally Geophilids are obtained from understones and in soft soil on land. One form in particular was obtained in good numbers from loose moist soil along with Polychaete worms of the genera *Marphysa* and *Lycastis*. This is a peculiar habitat for a centipede. In 1889 *Geophilus submaritima* was recorded to live close to the low watermark of very low spring tides where it could not be exposed more than two days in a fortnight. *Linotenia maritima* and *Schendyla submarina* are also known from the shores of Western Europe beneath stones at low watermark. (*S. submarina* is probably a synonym of *G. submaritima*.)

The present paper describes the forms and discusses the habits and anatomical peculiarities of those obtained in the mouth of the river Cooum where the water is brackish.

17. The development of the vertebral centrum in *Clupea*.

S. G. MANAVALA RAMANUJAM, Madras.

The centrum, by which is meant that portion of the vertebra which remains after the projecting parts have been removed, is formed after the arches have been laid and independently of them. It originates in two parts. The first part is derived from the ossification of the outer part of the fibrous sheath surrounding the notochord; the other is developed outside the first part as membrane bone by the ossification of the surrounding connective tissue layer ("membrana reuniens"). The membrane bone forms the greater part of the centrum and partly contributes to its double-cone shape by its growth over the sides of the raised intervertebral ring.

The immigration of skeletogenous nuclei into the sheath is practically nil, nor is there any pre-formation of any part of the centrum in cartilage. The arches do not contribute to the formation of the centrum. The *elastica externa* persists for a long while between the two layers of the centrum.

In thus being formed partly from the sheath and partly from the perichordal skeletogenous tissue, the *Clupea*, in the formation of their centrum, represent a connecting link exhibiting both the Elasmobranch or the chorda-centra and the higher Teleost or the Perichordal-centra type of development of the vertebra.

It is shown that the term "Arci-centra" is inapplicable as a rigid point of distinction of the vertebra in Teleost.

18. The genus *Paradistomum* in Burmese reptiles.

G. D. BHALERAO, Muktesar.

The author has described in this paper a new species of trematode *Paradistomum* from the intestine of a Burmese reptile *Gecko verticillatus* and a new variety of the species *Paradistomum magnum* Tubangui 1928 from the gall bladder of *Mabuia dissimilis*. Short descriptions of *Paradistomum mutabile* (Molin 1859) from the liver of *Acanthosaurus major* and *Paradistomum magnum* from the gall bladder of *Hemidactylus gleadowi* are given. While propounding the new species all the recorded species of the genus have been taken into account and are divided into two natural groups: one with cirrus-sac much anterior to ventral sucker and the other with the cirrus-sac resting on ventral sucker or partly overlapping it. From the species of the first group the new species is separated and the arguments for so doing are offered. In the case of the specimens from *Mabuia dissimilis* the oral sucker being terminal instead of sub-terminal as is usually the case in the species *P. magnum*. The species from *Hemidactylus gleadowi* resembles *Paradistomum magnum* of Tubangui obtained from the gall bladder of *Hemidactylus frenatus*, but the author is not in agreement with Tubangui as regards the points of its separation from *Paradistomum mutabile* utilised by him, so the new arguments for its separation from *Paradistomum mutabile* are offered, and the specific diagnosis of *Paradistomum magnum* is given in the light of the new observations.

19. A new Acanthocephalan from *Ophiocephalus striatus* a common food-fish of Nagpur.

G. D. BHALERAO, Muktesar.

The author has described in this paper a new form of Acanthocephala from the duodenum and intestine of a common food-fish of Nagpur *Ophiocephalus striatus* and has offered a discussion of its systematic position.

20. Effect of temperature and humidity on the delivery of young and the development of the embryo in lac insect (*Laccifer lacca*).

P. S. NEGI, S. N. GUPTA and M. P. MISRA, Namkum.

The experiment was carried out in cooling chambers, with (1) single cells, and (2) brood lac sticks. It was found that the mother could be prevented from laying eggs at a temperature of 14-17°C in July and August for a period of 6-12 days, without killing her. The development of eggs which would be laid in 5-8 days could be retarded to 16-18 days at a temperature of 12-20°C. The larvae stop movement at a temperature of 20-22°C and can be prevented from coming out of the incubating chambers for 4-5 days after which they die of hunger. Humidity seems to play no part in the delivery of young. The laboratory temperature was about 25-27°C.

21. *Chalcis tachardiae* Cam. hyper-parasite on *Eublemma amabilis* and *Holcocera pulverea*.

S. N. GUPTA, P. S. NEGI and M. P. MISRA, Namkum.

The Chalcid hitherto was only found hyper-parasitic on *Holcocera pulverea* as far as lac insect is concerned, but it has now been found

hyperparasitic on *Eublemma* also. One meets with types of two definite sizes of this Chalcid, and we are of opinion that the bigger type is parasitic on *Eublemma* and the smaller on *Holococera*.

22. A note on *Brasema annulicaudis* Cam.

S. N. GUPTA, P. S. NEGI and M. P. MISRA, Namkum.

The paper describes the male, the larva and pupa of the species; the copulation in adults; its seasonal history and the alternative hosts.

23. A note on the relation between the intestine and the style-sac in some South Indian freshwater gastropods.

R. V. SESHAIYA, Tirupati.

In spite of much recent work on crystalline style and its associated structure in gastropods, the relation between the style-sac and the intestine in some gastropods needs elucidation. Among the common South Indian freshwater gastropods, two types of crystalline-sac occur. One type is represented in *Paludomus* and *Melanoides*. The other type is represented in *Mysorella* and *Amnicola*. In the former type, the style-sac, though separate from the intestine shows a slit like communication with the commencement of the intestine. This communication is restricted to the region of the opening of the style-sac and it is the termination of a ciliated groove found in the style-sac on the pyloric side. In *Mysorella* and *Amnicola* the pylorus is well developed and it communicates with the style sac throughout its length. This condition resembles the one described by Robson in *Paludetrina* and *Hypsobia*.

24. On the habits and anatomy of *Mysorella costigera* Küster.

R. V. SESHAIYA, Tirupati.

A preliminary note on the habits and anatomy of *Mysorella costigera* is given.

25. Some notes on the arterial system of a common Indian toad *Bufo melanostictus* Schneid.

J. L. BHADURI, Calcutta.

The arterial system of the genus *Bufo* is not very much known. Crawshay (*P.Z.S.*, 1906), in his article on the variations of the arterial systems of the Anura, has made some observations on one specimen each of *Bufo boreas* and *Bufo mauritanicus*. On the other hand, the arterial system of *Bufo melanostictus*, one of the common Indian Anuran types commonly used for dissection in nearly every Indian University, differs so much from other described species of Anura that the author considers fit to record here the following notable features:—

(i) The *occipito-vertebral artery* before dividing into its two branches gives off from near its base a branch supplying chiefly the dorsal wall of the pharyngeal region.

(ii) The *oesophageal artery*, unlike the condition in other Anurans, is always single and arises only from the left systemic arch a little further off from the origin of the subclavian artery. The *oesophageal artery* in the same situation has also been observed by the author in *Bufo stomaticus*.

(iii) The *posterior mesenteric artery* is totally absent.

(iv) *Lumbar arteries* are absent.

26. The anatomy of a common Indian species of *Anura* Gerv.

DURGADAS MUKHERJI, Calcutta.

The anatomy of insects of the order Collembola has not attracted much attention in India. The author deals with in detail the mouth parts, anatomy and histology of a common species of *Anura* Gerv., that occurs in plenty in Calcutta. The mouth parts offer considerable peculiarity in the structure of the maxillae. The maxilla of each side possesses a bipinnate appendage and three teeth at its apical region. Among the peculiarities in the digestive system may be mentioned a pair of diverticula extending into the head. Nervous system, reproductive system and unicellular glands present in the head region are also described.

27. Cyst formation in culture of *Pentatrichomonas bengalensis* Chatterjee, 1915.

KHAGENDRA NATH DAS, Calcutta.

The cyst of *Trichomonas hominis* has not so far been recorded. The cysts of *Trichomonas hominis* claimed by some authors belong, according to Dobell, to species other than *Trichomonas hominis*. The author here puts on record a case of encystation in culture of *Pentatrichomonas bengalensis*, the tropical representative of *Trichomonas hominis*. The stool from which the specimens were obtained was free from any other flagellates and care was taken to avoid contamination of any sort. The cysts are spherical bodies, 6μ to 12μ in diameter and present characteristic features of the *Pentatrichomonas bengalensis*.

28. Zoogeographical results from a study of the Asiatic *Corbiculas*.

B. PRASHAD, Calcutta.

In connection with his systematic revision of the Asiatic freshwater molluscs the author has selected genera which seemed to be interesting for the study of distribution of these forms in different parts of the globe, and which may help to elucidate the lines of dispersal of these animals and thus clear up the difficult questions of the probable land connections between various continents, on the one hand, and between different parts of the several continents themselves, on the other.

In the last session of the Science Congress the author read a paper on the results of his studies on the gastropod family Viviparidae, and showed that the distribution of the members of this family, both recent and fossil, is very peculiar. The recent members of the Viviparidae have a very peculiar and discontinuous type of distribution and as the means of dispersal are limited, this distribution could only be explained by assuming a polyphyletic origin for the different members on the one hand and by accepting some of the previously suggested land-connections and the alterations in the courses of the present day river systems, on the other. The studies on the genus *Corbicula*, a member of the family Cyrenidae, a freshwater Lamellibranch, have resulted in confirming many of the conclusions which were put forward in the paper on the Viviparidae. Though the author has not had the opportunity to study the *Corbiculas* from different parts of the world with the same thoroughness as the Viviparidae, and has so far confined his attention to the Asiatic species, there can be no doubt that the relationships of the recent forms in different parts of Asia are more or less the same as those of Viviparidae, and with the means of dispersal for the two families being almost the same, this was naturally to be expected. The results of the author's investigations are not quite complete, but it may be noted that the zone of distribution of the genus *Corbicula* in south-eastern Asia is practically

identical with that of Viviparidae. In the far west, however, in which the author includes the western half of the palaearctic region in Asia there is a very pronounced element of the geologically very old palaearctic species—*Corbicula fluminalis* (Müller); this species, which is not found as a recent form in Europe has a somewhat different distribution from that of the palaearctic Viviparidae, but the general conclusions do not seem to be very much affected by this solitary exception.

29. Preliminary observations on the fish fauna of the Indawgyi lake in Northern Burma.

B. PRASHAD and D. MUKERJI, Calcutta.

In the last session of the Science Congress at Calcutta Dr. B. N. Chopra of the Zoological Survey of India made certain remarks on the fauna of the Indawgyi lake in Northern Burma. The collections made by the officer in the area had not then been worked out, and it was not therefore, possible to go into details at the time. We have since systematically worked out the fish collected in that area, and propose giving a short summary of the outstanding features of our work, and shortly to discuss the probable relationships of the fish of this area with those of the surrounding parts.

The fish fauna of the lake is very rich, and is represented by the families Chaudhuriidae, Symbranchidae, Siluridae, Cyprinidae, Clupeidae, Notopteridae, Belontiidae, Percidae, Nandidae, Rhynchobdellidae, Ophiocephalidae, Anabantidae, Syngnathidae, a new family allied to the Syngnathidae and Tetraodontidae. In all 69 species of 46 genera were found in the collection. Three new genera of the families Cyprinidae, Anabantidae, and of the new family allied to Syngnathidae and ten new species are described in the paper. Other outstanding forms are a species of the genus *Chaudhuri* which appears to be identical with *C. caudata* Annandale from the Inle lake, Southern Shan States, *Xenentodon cancila*, *Doryichthys* sp. and *Tetraodon cutcutia*. The three latter species as also the new Lophobranchiate are nearly allied to estuarine forms and must have originated somewhere near the sea. At the present time the Indawgyi lake is not directly connected with the sea, the nearest connection through the Irrawady river is very indirect and the intervening area is several hundred miles long. The presence of such forms and particularly that of the highly specialized Lophobranchiate suggests a much closer connection in the earlier times. The species, it may be noted, was found only in the lake and not in any of the streams which open into it.

The general faunas of the fish fauna is very similar to that of the Indo-Burmese area. Compared with the fish fauna of the Inle lake in the Southern Shan States, it may be noted, that the fauna is much richer and the greater number of the species found in Inle lake are also present in the Indawgyi lake.

30. The influence of physical factors temperature and humidity on incubation of eggs of *Dysdercus cingulatus*. Fabr.

DEV RAJ MEHTA, Lyallpur.

Moisture associated with temperature plays an important role in the incubation of the eggs of *Dysdercus cingulatus*. Eggs hatch in 5-6 days at 86-95°F. The incubation is prolonged to 10-11 days at temperature 68-82°F and finally at very low temperature 60-72°F eggs hatch in 18-26 days. Eggs fail to hatch at temperature below 60°F and above 95°F.

Eggs kept at alternating high and low temperatures and uniform humidity behave differently. The rate of development of eggs is consider-

ably accelerated at alternating high temperatures, (95°F and 90°F). When the range of high and low temperature is wide (95°F and 80°F) the incubation period is prolonged accordingly. Hatching of eggs at alternating high and low temperature depends on the exposure received. Even at suitable temperatures 70°F–90°F, low humidity (7%–30%) inhibits the development of eggs. Critical humidity depends on the prevailing temperature. Excessive moisture is in no way injurious to eggs, in fact at high temperatures 94°F–96°F, incubation of eggs is considerably facilitated, when the atmosphere is fully saturated. Incubation period is however unaltered by the amount of moisture present in the atmosphere, temperature being the dominant factor.

31. A new species of trematode parasite of the genus *Prymno-prion*.

P. W. GIDEON, Dharwar.

While working on the trematode parasites of vertebrates in Dharwar, the author came across two specimens of a new species of the genus *Prymno-prion*, found in the rectum of *Ibis melanocephala*: Looss, in his work on the trematode fauna of Egypt, describes 3 species of this genus, and though this specimen has many features in common with the others, it possesses certain other characteristics of a specific nature.

Details of the parasite and the main points of difference from the existing species, together with photomicrographs and drawings of the 2 specimens, are given in the paper. The smaller specimen seems to be immature, and it will be noticed that the vitellaria are not as well developed as in the larger specimen. The description is that of the larger specimen.

32. On the occasional presence of a 'valve' in the carotid arch of the Indian Bull-frog (*Rana tigrina*) and further observations on the paradoxical valve (valvula paradoxa) of Gaupp.

N. K. SINGH, Agra.

While examining serial sections of the heart of *Rana tigrina* it was found that a 'Valve' is present inside the carotid arch (canalis caroticus). No mention has yet been made of such a valve in the Canalis Caroticus of *Rana tigrina* or any other Amphibian; but a similar valve observed first by Burcke and afterwards by Boa, Sebatier and others has been mentioned by Gaupp (*Vide* Ecker and Wiedersheim's *Anatomic des Frosches*) in the systemic arch (canalis aorticus) of *Rana esculenta*. Gaupp designates it as 'valvula paradoxa.' I prefer to designate the valve present in the canalis caroticus (Carotid arch) as 'valvula carotica' to distinguish it from Gaupp's 'valvula paradoxa' which is only found in the systemic arch.

Summary of observations and conclusions:—(i) The valvula carotica or the carotid valve lies inside the carotid canal of both the right and left side. It begins a little above the origin of the carotid arch and extends up to the carotid labyrinth (the so-called carotid gland). In fact it is, so to say, a longitudinal valve approximately akin to the longitudinal or spiral valve of the truncus arteriosus of frog. It is formed as a protuberant mass from the dorsal wall of the carotid arch and in cross-section appears as a fringe freely projecting or hanging in the lumen of the carotid arch. In histological features it is similar to the spiral valve and the valvula paradoxa. (ii) I have been able to find 'valvula carotica' only in few specimens. The 'valvula paradoxa' of Gaupp is also of rare occurrence and like the 'valvula carotica,' is present in some specimens and absent in others. Of the specimens under observations, some showed the presence of both the valves (*viz.*, valvula paradoxa and

valvula carotica) and in such cases, the valves seem to fuse with each other at the junction of the aortic arches and project, so to say, in a common lumen formed by the union of the carotid and systemic arches, on each side of the truncus. (iii) The occurrence of valvula carotica in limited cases seems to me an abnormality. As to its function and significance, I have not been able to investigate thoroughly for want of material and proper facilities. It seems to me :—

- (a) to regulate the flow of blood and like other valves in heart and veins it checks the regurgitation or (reflux) of the amount of venous blood.
- (b) It may be a primitive feature or condition and recalls the fact, that in some Indian Teleostean fishes a similar longitudinal fold or valve designated as 'aortic ligament' (Burne, Bhattacharya) is present in the dorsal aorta, of which the probable vestiges we find in the truncus, systemic and carotid arches (of the amphibian successors) in the form of spiral valve, the valvula paradoxa and the valvula carotica respectively.

33. *Cercaria indicæ* XLVI, n.f.

ABDUL JABBAR FARUQI, Aligarh.

The cercaria was found in *Indoplanorbis exustus*, which were collected from some ponds in Handia, a village near Allahabad. It measures, 186 mm. in length and 111 mm. in breadth. The body is totally devoid of pigment, hence the study was done in the living condition. The sub-terminally situated mouth leads into a long prepharynx, which is followed by a very well developed pharynx. The pharynx is followed by a narrow oesophagus which ends in a slight dilation. There is no trace of intestine. The excretory system of this *Cercaria* differs in a number of marked features from the members of the Agilis, Reflexæ and Echinostome groups. In its general plan it resembles the members of the *Echinatoides*, but there are marked distinguishing features (e.g.), the main excretory duct does not divide into an ascending and descending branches; there are no side branches of the caudal canal. It seems probable that in the course of evolution the general character of the excretory system has undergone a progressive development, and *Cercaria indicæ* XLVI represents an intermediate stage.

The cercaria develop in radia.

The work was done in the Zoology Department, University of Allahabad, under the guidance of Dr. H. R. Mehra, Ph.D.

34. Excretion in *Melipona* during metamorphosis.

C. J. GEORGE, Coimbatore.

This paper postulates the presence of a temporary excretory system in the *Melipona* bee during metamorphosis, when the malpighian tubules do not function. This consists of a group of fat cells which become modified during the pre-pupal stage for performing that function. They disintegrate in the adult. They contain in their cytoplasm urate crystals and calcareous bodies. On account of their resemblance to the nephrocytes they have been termed pro-nephrocytes.

35. Two new and remarkable genera of Thysanoptera from South India.

T. V. RAMAKRISHNA AYYAR, Coimbatore.

In the course of his studies on Indian Thysanoptera the author recently discovered two insects of this order showing very remarkable

peculiarities. One was collected from flowers of the date palm (*Phoenix dactylifera*) at Nayudupetta near Madras, and the other at Bangalore from peculiar galls on leaves of white babul (*Acacia leucophloea*). A comparison of the characters of these two with those of closely allied forms recorded till now, shows that those two are not only new species but also deserve new generic rank in each case.

The first belongs to the *Heterothripidae* and is not identical with any of the known species of the only known living genus of the family, viz., *Heterothrips* Hood. The insect is also remarkable since it appears to be the first living Heterothripid to be recorded from the Eastern Hemisphere.

The Bangalore form belongs to the *Phloeothripidae* and though showing Phloeothripine characters is not identical with any of the genera of the Sub-family *Phloeothripinae*, as it exhibits remarkable features in sculpture of the body surface and in the shape of the bristles.

In this paper brief descriptions are given of the two forms pointing out their affinities and distinguishing characters which justify the bestowal of new generic and specific rank on them.

36. Bionomics of the tasar silk worm (*Antheroea paphia* Linn.) in South India.

P. N. KRISHNA AYYAR, Coimbatore.

This paper is the outcome of certain experiments carried out in breeding tasar silk worms in captivity with a view to gaining definite knowledge concerning their life-cycle and habits under the conditions obtaining in South India particularly with reference to the possibility of their domestication about which there are conflicting opinions. An attempt is made to present the methods of rearing found suitable in the laboratory together with a detailed account of the life-history, distribution, habits etc., in relation to South Indian conditions. Brief descriptions are given of all the different stages of the insect including the time occupied by each. The whole life-cycle which might vary slightly with seasons and temperature occupies about 57 to 132 days. Apparently *Terminalia catappa* seems to be its favourite food in this province though it has been noted in varying numbers on a few other plants. The results of observations on the longevity of the adult are also recorded.

37. Spermatogenesis of *Gryllotalpa africana*.

D. BHATIA and W. FERNANDO, Colombo.

The primary spermatogonium has a round nucleus surrounded by a narrow layer of cytoplasm. On one side of the nucleus there is a mass of mitochondrial granules.

In the growth phase some mitochondria grow and form large granules and long rods. The nuclear chromatin forms a spireme which contracts to form eleven chromosomes.

At the maturation division the rod-like mitochondria arrange themselves on the spindle, and chromosome pairs separate one daughter cell receiving five and the other six. The unpaired idiochromosome is about twice as large as the autosomes. The mitochondrial threads seem to break in the middle and get halved in the daughter cells.

The Spermatid has a comparatively small nucleus. Micromitochondria are scattered but rod-like macromitochondria gather on one side of the nucleus and form a vacuolated 'Nebenkern.' The centrosome of the last division persists and divides; the two granules come to lie on opposite side of the nucleus. Axial thread appears from one while the other forms the Acrosome.

The cell elongates, the nebonkern-halves get drawn round the axial thread and form a mitochondrial sheath round it which shows bleb-

like swellings. The nucleus develops chromatic lining and elongates to form a spindle-shaped head of the spermatozoon.

38. A Note on the Excretory system of *Discocotyle sagittatum*
Leuckart, 1842.

G. S. THAPAR, Lucknow.

Little work has been done on the Excretory system of Monogenea. In the present communication the author describes the excretory system of *Discocotyle sagittatum* which shows a very closed net work of tubes terminating internally in flame cells. The system in the present form is peculiar as it throws light on the origin of the Excretory system in Digenea.

39. On a new Trematode from the Intestine of *Tropidonotus piscator*.

G. S. THAPAR and FARZAND ALI, Lucknow.

Nicoll (1914) found a single specimen of *Ommatobrephus singularis* from the intestine of *Uromastix acanthinurus*. The form is peculiar in the position of the genital glands and the precocious development of miracidia while the eggs are still within the uterus. Recently, we have found in Lucknow, two distinct forms of Trematodes from the intestine of *Tropidonotus piscator*; one of these is *Acanthochasmus burminis*. Bhalarao (1926) and the other is new to science. This form resembles *Ommatobrephus singularis* in general characters but differs from it in the following features:—

1. The crura of the intestine extend backwards to the posterior end.
2. Testes are lobed and widely apart.
3. Vitellaria extend back from the posterior sucker to the middle of the testes.

40. Oogenesis of the Cockroach.

VISHWA NATH and PIARE MOHAN.

In a paper published in the Proceedings of the Royal Society, London (1920) Hogben described nucleolar extrusions in the egg of the cockroach which gave rise to albuminous yolk. Hogben carried out his work with fixatives containing acetic acid, although he did employ Flemming—without—acetic for the demonstration of the mitochondrial granules. In addition to confirming the nucleolar origin of albuminous yolk we have considerably extended these observations and have worked out the form and the fate of the Golgi elements in the egg of the cockroach not only by the help of the study of fixed preparations but also by the study of fresh cover-slip preparations stained with neutral red or treated with 2% osmic acid for a short time. In the youngest oocyte the Golgi elements can be seen in fresh cover-slip preparations in the form of vesicles. Simultaneously with the growth and increase in numbers of the Golgi vesicles, free fat is deposited inside their hollow interior and they are gradually converted into the fatty yolk which is distinct both in its origin and in its reactions to various fixatives from the albuminous yolk. The latter arises a long time after the fatty yolk has put in its appearance. It is interesting to note that the vacuoles figured by Hogben in the cytoplasm, about whose nature and origin the present authors did not say anything, are really the Golgi elements whose fatty contents have been washed out by acetic acid or by xylol in F.W.A. preparations.

41. The Egg of *Pheretima posthuma*.

VISHWA NATH.

If the ovary of the earthworm is kept in 2% osmic acid overnight and studied in the morning the Golgi elements appear as copper-coloured vesicles distributed uniformly throughout the cytoplasm. The mitochondrial granules appear yellowish and they are closely aggregated together to form a juxta-nuclear cap. With the growth of the oocyte the mitochondrial granules spread out throughout the cytoplasm and the Golgi elements increase in number. These latter do not swell up and become fatty as has been shown by the writer in *Lithobius*, spiders, *Luciola* and *scelopendra*, etc. The mitochondria as well the Golgi elements can be studied in fresh cover-slip preparations without any treatment with osmic acid or neutral red. There is no yolk, either albuminous or fatty, in the eggs of the earthworm.

42. Origin of Yolk in the Egg of the Red Cotton Bug, (*Dysdercus cingulatus*).

VISHWA NATH and KRISHAN GOPAL BHANDARI.

The advanced oocytes of *Dysdercus* contain two types of yolk, albuminous and fatty. If the ovary is kept in 2% osmic acid overnight and studied in the morning the albuminous yolk appears as solid, yellowish and round discs and the fatty yolk as black spheres. The albuminous yolk is nucleolar in origin and the fatty yolk, which is vacuolar, as shown by sections, comes from the Golgi elements. The latter in the youngest oocyte and in the follicle cells appear as hollow vesicles containing a watery substance. With the growth of the oocyte the Golgi vesicles grow in size and free fat is deposited inside their interior.

43. The Golgi Elements in the Spermatozoon of *Ascaris*.

VISHWA NATH and JIA LAL RAINA.

In addition to the spherical and large mitochondria which were demonstrated by Meves in his classical work, the sperm of *Ascaris* contains the diffuse type of Golgi elements. These appear as small osmophilic vesicles in the spaces between the large mitochondria which occupy practically the whole cytoplasm. Each Golgi vesicle shows an osmophilic rim and an osmiophobic central substance. When the sperms are studied in fresh cover-slip preparations stained with neutral red, the mitochondria appear as large spheres and the Golgi elements as small granules on their margins.

44. On the Spiders of Lahore.

SUKH DYAL.

A collection of spiders of Lahore was made by the author from June to November, 1928, in which 18 families, comprising about 60 genera and 150 species, are believed to be represented. The author also made observations on the life histories of two forms, as summarized below :—

1. *Araneus citricola*.

Each female lays as many as 12 cocoons. Each cocoon contains 50-70 eggs which are light orange in colour. The spiderlings hatch out of the eggs after 12 days; but remain within the cocoon. After the second moult the colour changes gradually from light orange to brown, then to dark brown, and finally to black. These remain inside the cocoon till some time after the second moult, usually 3-4 days. Sigilla and Lateral Streaks begin to appear 3 to 4 days after the second moult, and

at this stage spiders are seen hanging with their heads towards the ground. 5 days after the second moult the spiderlings exhibit red, white, brown and black colours. The increase in size is not uniform. Posterior bifurcation and shoulder prominences begin to appear just before the third moult. Males are black and smaller in size than females, their palpal organs appearing after the fourth moult. There is great variation in the size of females also. Majority of the females are white. Spinnerets remain quite short, and genital apertures are not visible till the last moult.

2. *Hippasa aglenoides*.

A round white cocoon containing nearly 70 pale eggs is attached to the spinnerets of the mother. Eggs hatch out after 12 days within the cocoon. Spiderlings are all white with dark heads. Second moult takes place two days later. At this stage the mother opens the cocoon and spiderlings come out of it and climb on her abdomen and are carried about by the mother for a couple of days. They then leave her and henceforth the mother takes no further care of her young, and may even feed on them. The colour is dark blue above and lighter below, and remains so till the fourth moult, after which the colour fades till the seventh moult when the spiderling is light brown in colour. There is no change in colour after this stage. Palpal organ in male appears after the eighth moult. Spinnerets remain quite short, and genital apertures do not develop till the last moult.

45. Some observations on the Moths of Simla.

N. K. GANGULI.

The author has been working on the Moths of Simla since last May. An extensive collection was made from July to September, which contains representatives of the families *Saturnidae*, *Sphingidae*, *Noctuidae*, *Arctidae*, *Lymantridae*, *Geometridae*, *Notodontidae*, *Drepanulidae*, *Cossidae*, *Eupterotidae*, *Pyralidae*, *Cymatophoridae* and *Lasiocampidae*, to the number of approximately 138 species. While doing systematic work the author made observations on the Life-history of *Gastropacha* sp., Coloration in *Sphingidae* and Flight in *Saturnidae*, an account of which is given in the paper.

46. Water-Bugs of Lahore and Batala.

HANS RAJ BHALLA.

7 families, 13 genera, and 40 species are represented in the collection made by the author, of which 11 species and 7 varieties are believed to be new to Science. The genera *Gerris*, *Metrocoris*, *Microvelia*, *Laccotrephes*, *Nectocoris* contain each one new species, and *Ranatra*, *Corixa* and *Micronecta* contain each two new species. Descriptions of the new species and notes on their habits and anatomy are given in the paper.

Section of Botany.

President :— PROF. K. C. MEHTA, M.Sc., Ph.D. (Cantab.).

Presidential Address.

THE ANNUAL RECURRENCE OF RUSTS ON WHEAT IN INDIA.

LADIES AND GENTLEMEN,

My first duty towards you is, to thank you, for the honour you have done me in electing me president of this section.

I owe you, an explanation, for selecting the "Wheat-rust problem" in this country as the subject of my address. Perhaps, a better place for an address like the one I am going to give you, would have been the Agriculture section.

I have purposely selected this subject, because during the last quarter of this century, there has been little work done on the factors of recurrence of these pests on wheat, as far as India is concerned; although this problem has been practically solved in many of the wheat growing countries in other parts of the world.

Secondly, it is time, that life-histories of those species of *Puccinia*, that are responsible for rusts on wheat and barley, be thoroughly worked out from the academic point of view as well, because, these types are prescribed for the B.Sc., and M.Sc., examinations in Botany by most of our Universities.

Besides I wish to discuss before you, the present position of the wheat-rust problem in India, as I see it, after working on it for a period of over five years.

INTRODUCTION.

Butler (3) in 1903 said "that no other diseases approach in their consequences to rusts." "That there are few diseases of plants so obscure as these and the difficulties instead of diminishing appear to increase with each succeeding advance of knowledge."

Howard and Howard (9) have also observed that "wheat rusts are of the greatest economic importance in India, and that a study of these diseases and of the means of combating them is imperative."

Ladies and gentlemen, I may have to disappoint those amongst you, who are expecting the last word in the solution of this great problem at this stage from me.

I propose giving you a brief account of recent work done on this problem outside India.

I am also going to tell you how this problem stands in India to-day, in the light of my own work, the greater part of which has not yet been published.

There are as many as three different rusts found on wheat in India and the life-history of none of them is yet completely known.

India is one of the most important wheat growing countries and taking the average for the last three years there are as many as 24,336,089 acres under wheat every year in British India alone.

Before dealing with the subject under discussion, I shall briefly describe the life-history of each of the three species of *Puccinia*, that cause rusts on wheat, as known in other countries; and I shall also draw your attention to the gaps, which have to be filled up in our knowledge of these pests, as far as India is concerned.

I shall illustrate the life-history of each species with the help of coloured lantern slides.

(i) General

Uredospores, their germination, entry of the germ tube via the stoma, sub-stomatal vesicle, infection hyphæ, normal period of incubation, formation of a uredo-sorus.

(ii) Yellow rust caused by *Puccinia glumarum tritici* Erikss. and Henn.

Only uredo and teleuto-stage known.

No intermediate host has so far been discovered anywhere in the world.

(iii) Brown rust caused by *Puccinia triticina* Erikss.

Uredo and teleuto stages on wheat.

Aecidial stage has been artificially produced by inoculations with sporidia on species of *Thalictrum* in U. S. America as recorded by Jackson and Mains (11).

Occurrence of the aecidial stage of this fungus on *Thalictrum* has been recorded in Russia by Shitikova-Roussakova (19) but these authors are doubtful if that is a factor of great importance as far as the fresh outbreaks of this rust on wheat are concerned.

Barclay (1) has stated that aecidium on *Thalictrum javanicum* and *Th. minus* occur near Simla but so far there is no evidence of its connection with the uredo stage of *P. triticina* on wheat as far as India is concerned.

(iv) Black rust caused by *Puccinia graminis tritici* Erikss. and Henn.

Uredo and teleuto stages on wheat and aecidial stage on species of *Berberis*.

In such countries where there is an undisputed connection between rusted barberry and wheat, the eradication of the former has been very effective in checking fresh outbreaks of this rust.

Denmark has been practically free from epidemics of this rust as a result of destruction of barberry as stated by Hansen (8).

In U.S. America a vigorous campaign of barberry eradication is going on and a considerable amount of propaganda is in force to persuade farmers to destroy that bush. Eradication of barberry has been recommended in several other countries where this pest is found.

That aecidia are found on barberry in India in the Himalayas has long been known, but their connection with the rust on wheat has not been established so far in this country.

WHEAT-RUST PROBLEM IN INDIA.

Of all the wheat growing countries in the world, the cereal-rust problem is least understood in India.

The absence of any alternate hosts on the plains, and the long distances to such hill stations, where barberry and *Thalictrum*, the two probable alternate hosts grow, complicates the issue and render investigation still more difficult.

In spite of the absence of suspected alternate hosts on the plains, the rusts under report do great damage to our wheat crop year after year.

POSSIBLE FACTORS AND THEIR RELATIVE IMPORTANCE.

In a previous publication (13) I have discussed the relative importance of:—

(i) Direct infection of wheat by sporidia from germinating teleuto-spores.

(ii) Infection through an internal, inherited and an invisible germ of disease inside the seed grain as stated by Eriksson (6).

(iii) Infection from teleuto-sori on seed as suggested by Pritchard (17).

(iv) Part played by alternate hosts like species of *Berberis* in the case of *P. graminis* and *Thalictrum* in the case of *P. triticea*.

(v) Lastly the importance of viable uredo-spores, that occur during the critical periods on self-sown plants, as a factor of special importance in the case of *P. glumarum* and *P. triticea*.

On account of the differences in the climatic conditions, the incidence of rusts in different countries is bound to be different.

Apart from its incidence one has to make sure, whether, a certain rust can or cannot pass the unfavourable period on self-sown plants, in the form of uredospores or as mycelium inside the tissues of the normal host.

As a result of careful search extending over two years, coupled with laboratory and field work, on the culture of all

the three rusts under report, I came to the conclusion, that in the case of *P. triticina* and *P. glumarum* the presence of viable uredospores at the time when the crop is sown and the power of the fungal mycelium to withstand low temperatures are factors of outstanding importance, as far as the annual recurrence of these two rusts is concerned, in the neighbourhood of Cambridge.

The period between the harvest and the sowing of the new crop being hardly two months, the new crop gets infected by uredospores available in plenty, on self-sown plants in the neighbourhood. The infection of the new crop is followed by a long incubation period due to cold. During the period of incubation the mycelium inside the host plants may be growing by fits and starts and ultimately results in rust outbreaks. What is true of Cambridge is, in a general way applicable to most of the countries where the critical period is the severely cold winter. At places with a milder winter the possibility of the survival of uredospores is still greater and outbreaks of rust may take place on the new crop after a shorter period of incubation.

In this connection, I may also point out that the uredospores of both *P. glumarum* and *P. triticina* can stand cold better than *P. graminis*.

The annual outbreaks of *P. graminis* in such countries where the uredospores of this rust cannot overwinter, can be explained either by fresh infection through aecidiospores produced on barberry, or by uredospores blown by wind from foci of earlier attack due to surviving uredospores.

I shall refer in detail to such localities later.

INCIDENCE OF RUSTS AND CLIMATIC CONDITIONS ON THE PLAINS OF INDIA.

Wheat with us is a cold weather crop, sown from the last week of October up to the middle of November and is harvested in March-April on the plains.

Rusts on this crop do not ordinarily appear before the latter half of January on the plains. A careful observation in the fields, at the time of the fresh outbreak, will show that plants are not infected from base to apex but a leaf here and a leaf there shows sori at odd places. Leaf areas covered with sori are so irregularly scattered that infection from within the host plants seems impossible.

In view of this incidence, I wish to emphasise at the outset, that no infection seems possible through teleutospores germinating on the soil or teleutospores on the seed grain. Nor does the suspected internal germ called "mycoplasma" come into play.

If any one of these factors did count, it is difficult to understand, why rusts should not appear on the crop within a week or two after the crop is up in the month of November.

Howard and Howard (9) suspected that uredospores of rust may lie in the soil in the resting condition and then infect the new crop.

I may quote at this stage, that conditions of weather on the plains in the latter half of October and November, are favourable for a rapid growth of the rust mycelium and that the period of incubation is normal (7-10 days) as actual experiments have shown.

Consequently the fact, that wheat crop raised on the same plots which showed good deal of rusts in the previous season keeps healthy for as long as three months, proves that infection from uredospores produced in the previous season is not possible on the plains.

I shall refer to this aspect of the problem later and quote evidence from experiments conducted on the viability of uredospores.

Butler (3, 4) has already referred to the extreme unlikelihood of rusts spreading from wild grasses to wheat in the plains of India. In the first place rusts on grasses are so different morphologically and physiologically from those on wheat and no suitable collateral hosts have so far been discovered. Besides, it is improbable, that uredospores can survive the summer heat on grasses either.

I have not come across any rusted grass in summer and during the monsoon on the plains.

SURVIVAL OF UREDOSPORES IN THE HILLS.

My previous work, referred to above, suggested to me the possibility of the survival of uredospores up in the hills in this country because of a cooler summer and on my return from Cambridge I started making a search for viable uredospores on self-sown plants in the Kumaon hills in 1923.

In 1925 (14) I read a preliminary note on the annual recurrence of yellow and brown rusts in this country before this section.

I stated then that on account of the intense heat of summer, there is little likelihood of uredospores surviving from the previous crop on the plains, which they do in cold countries.

Uredospores survive the summer at such hill stations where climatic conditions are favourable. Uredospores, (probably) the only source of infection, blown by wind from such localities may start infection on the new crop on the plains.

For a period of over five years I have been studying this problem in its different aspects. Frequent visits to suitable places in the Kumaon and Simla hills, have been paid at different times during this period to study the incidence of rusts at different altitudes. The incidence of rusts on wheat and barley has also been very carefully studied at several places on

the plains of the United Provinces of Agra and Oudh during the same period. Side by side with field work a good deal of experimental work on the culture of rusts, study of the viability of uredospores and allied phenomena has been conducted.

The conclusions I have come to are the following:—

(A) INCIDENCE OF RUSTS ON THE PLAINS.

(i) Self-sown plants are practically absent during May–September and the few that have been found were quite free from rust.

(ii) No rusted grasses either are available during the greater part of the period mentioned above.

(iii) No rust on wheat has been observed on the plains before the end of January except at places at the base of the hills or near about.

(iv) Every year rusts have been observed at Haldwani and Kathgodam (at the base of the Kumaon hills) a week or two earlier than at Agra and places in the neighbourhood.

(v) Plant to plant, rusts are severer in their attack at the base of hills at a time when they are just appearing at places farther away.

(B) INCIDENCE OF RUSTS AT MUKTESAR.

(i) Viable uredospores of *P. glumarum* and *P. triticea* have been observed several times in September–October on self-sown plants and tillers of wheat near Muktesar at an altitude of 7,600 ft. above sea level.

(ii) These plants have been observed in large numbers on plots of land left alone after the harvest, along the hedge, and in debris at places where wheat had been thrashed.

From a casual observation, one is apt to conclude, that there is no rust at the locality. After a more careful search one is sure to find, along with healthy plants, several bearing uredo-sori of yellow and brown rusts. Rusted plants are very common on plots rather protected from direct sun. After a more patient search one may find even plants in ear and covered all over with uredo-sori of one or both the rusts. That has been my experience on every occasion when I have searched for them.

(iii) Many wild grasses and plants of the Family Compositæ, Rosaceæ and others are found badly rusted at that locality in September–October.

(iv) *Aecidia* on species of *Berberis* particularly *B. aristata* are very common at that time of the year at an altitude of 5,000–7,000 ft. on the way to Muktesar.

WIND-BLOWN UREDOSPORES AS SOURCE OF INFECTION.

At this stage I may refer to the observations made by Klebahn (12) who has expressed the possibility of rust sporophores

being blown by wind from other continents and such spores being responsible for fresh outbreaks of rusts in different parts of the world.

To be brief, it may be stated that on account of the absence of rusts on our crop in the plains for nearly three months after it has been sown, it is very unlikely that spores are blown down to the plains here during October-December from other continents.

Again yellow rust which is so common here is not found either in Australia or South Africa.

Believing in the possibility of both black and brown rusts being present throughout the year in South Africa and Australia, it is difficult to understand, why uredospores from those continents do not infect our crop before January-February. We must then look for infection to more distant continents, like Europe and America. It is still more unlikely, for reasons given above, that our crops take infection from uredospores that have been blown down from across the oceans.

It is needless, however, to go so far when the source of infection lies so near at hand. I (14) have already expressed the possibility of the dissemination of uredospores by wind, from such localities where they have been repeatedly found in a viable condition during the critical period.

On the basis of the survival of uredospores in the hills and an earlier attack every year of rusts at places near the base of such hills it is right, I believe, to conclude that our wheat crop on the plains gets infected by wind-blown spores as already suggested by me in 1925.

By the circuitous hill path Muktesar is 28 and 24 miles respectively from Haldwani and Kathgodam (on the plains). The distance is considerably less as a crow flies and as the winds travel, so that infection from wind-blown spores does not need much of an explanation.

The reason why our crop on the plains is not infected by such spores earlier than January may be explained as follows:—

Our crops on the plains normally are not up before the middle of November, by which time, the weather in the hills becomes very cold, as the following tables will show. Consequently, the incubation period of the fungus in the hills is prolonged, and there is not much of material available at that time.

Data of average temperatures of Muktesar for 3 years.

1924-25.

			Max.	Min.	Mean.
November	63.2°F	38.3°F	48.7°F
December	60.4 "	32.0 "	45.7 "
January	56.0 "	23.7 "	37.5 "

1925-26.

November	64.6 "	38.0 "	47.6 "
December	59.6 "	33.9 "	45.3 "
January	55.8 "	27.5 "	40.0 "

1926-27.

November	61.4 "	32.7 "	45.2 "
December	64.2 "	30.3 "	44.4 "
January	62.2 "	27.5 "	38.8 "

In milder weather, rusts on the hills will spread faster and there is nothing to prevent their dissemination to the plains a few weeks earlier.

There are two other factors we have to bear in mind in this connection.

One is the direction of the prevailing winds during November-February and the other is the humidity of the air without which germination of spores would be difficult.

Both these factors are rather unfavourable for the establishment of rusts on our crop during November, as will be clear from data given in the latter part of this paper.

It may also be noted, that the incubation of rusts, even in the plains, in December is longer than the normal. It is nearly 12-14 days and may be longer still if there is a cold wave.

Infection of the new crop by uredospores from self-sown plants at a place like Muktesar does not need much of an explanation. It is interesting to note that yellow rust takes an epidemic form on the crop at Muktesar fairly early in the year. Wheat plants hardly six inches long were found badly rusted at that locality in the first week of January, 1928.

It is only natural, that the mycelium of the fungus inside the host should get a good start in bright sun during the day and, in spite of cold nights, the total length of the incubation period at a place like Muktesar may be shorter than what it is in some of the coldest countries like Sweden and Norway.

In a previous publication (13) I have discussed in detail, the influence of low temperatures on the length of the incubation period.

A cold wave during November and December with frequent snow will prohibit rapid growth of the mycelium at

places like Muktesar. A comparatively mild weather will lead to an earlier appearance. Consequently, the dates of the first outbreak of rusts may not be the same in any two years.

SURVIVAL OF UREDOSPORES FROM PREVIOUS CROP AS STUDIED IN OTHER COUNTRIES.

Reference may here be made, to my work done at Cambridge, on the strength of which it was concluded, that "for the annual recurrence of yellow and brown rusts, the factor of the greatest importance is the occurrence of plenty of uredospores on self sown-plants and tillers, at the time when the autumn-sown crop appears."

References to work published before the year 1923 have already been made in that paper and need not be repeated here.

That the first outbreaks of rusts are no longer so baffling and have been satisfactorily explained on the basis of the survival of uredospores in other countries also will be clear from Hungerford's (10) work done on yellow rust in United States of America. This author writes that seedlings infected in autumn may be a common method of carrying the disease through winter.

Russakov (18) has recently shown that in Russia also the stubble remaining in the fields after harvest and up to the time of the sowing of the autumn cereals is the most dangerous source of infection.

Stakman (20) has also stated that uredospores of *P. graminis* live through winter near San Antonio and other places equally far south. They seldom overwinter as far North as Dallas Tex.

WIND-BLOWN SPORES OF RUSTS AS THE SOURCE OF INFECTION IN OTHER COUNTRIES.

Miss Newton (16) observed that the problem of the control of wheat stem-rust is different in Canada from that in the United States. There are not sufficient barberry bushes to account for the great rust epidemics. There is no evidence to show that uredospores can live through the long Canadian winter. "The generally accepted hypothesis is that rust moves Northwards from the United States."

Recently Gussow (7) has stated that in Canada there is no over-wintering of uredospores of wheat stem-rust. Observations were made by him and his colleagues with the help of spore traps exposed in aeroplanes at altitudes between 1000-5000 ft. above sea level and stationary glass slides smeared with a thin layer of vaselin with the idea of discovering the initial source of infection.

Data from several stations towards the South and North

of Canada were collected and the conclusion arrived at is as follows:—

“Almost in proportion as the station is situated further West or North the amount of inoculum is gradually diminished and the date of the arrival of rust is retarded.”

This work suggests that the source of infection is blown by Southerly winds from U.S. America into Canada.

Shitikova-Roussakova (19) worked on similar lines in Russia and a satisfactory explanation of the spread of *P. triticea* and *P. graminis* from North Manchuria to the Amur region has been given.

In North Manchuria these two rusts are said to over-winter in the uredo stage which they do not in the Amur region. Rust spores are blown to the Amur region from North Manchuria by Southern winds

Similarly Stakman (20) has expressed the possibility of infection of cereals by uredospores of stem-rust blown by Southern winds to the North where the rust cannot over-winter in the uredo stage.

I feel, that enough has been said on this topic and one may safely conclude, that rusts are spread by winds from foci of earlier attack at places where the uredospores can live during the critical period on account of a milder climate.

CAN THE UREDOSPORES OF ANY OF THE THREE RUSTS OF WHEAT SURVIVE THROUGH SUMMER ON THE PLAINS OF INDIA?

Butler and Hayman (5) have expressed that it is very unlikely for uredospores to retain their viability after exposure to temperatures above 100°F. The maximum temperature in shade in the Indo-Gangetic plain being above 100°F. for weeks and the soil being exposed to still higher temperatures, it is doubtful if uredospores can live through that period. They have also observed that uredospores exposed to the sun for some hours when the shade temperature was 90°F. lost all viability.

Butler (4) has remarked that five minutes moist heat at 113°F. is enough to kill all the uredospores.

During the last two years, from a month to one week before harvest, I conducted some experiments at Agra with Hearson's nine compartment incubator, on the effect of different temperatures on the viability of uredospores. The range of temperatures used was 32°C–47°C in the incubator and including the room temperature on one hand and the temperature of a paraffin oven on the other the total range was between 22°C–52°C in most of the experiments. Material of uredospores used for these experiments was as nearly of the same age as possible. In some of the experiments only such material was used as had been grown in a pot culture cage and the material kept in each compartment was exactly of the same age.

In order to prevent drying of leaves and stems the stalks were kept dipped in specimen tubes half full of water. By this treatment the leaves kept perfectly fresh. The following is a brief summary of the results obtained:—

(1) *P. glumarum*.—Fresh uredospores of this rust collected early in March showing nearly 50% germination suffered a gradual decline from 40% at 30°C to hardly 2% germination at 47°C after 3 hours' treatment.

The control kept for 18 hours at a constant temperature of 28°C (the room temperature as registered by a thermograph) showed over 30% germination. After 18 hours' exposure in the chamber at 42°C all viability was lost.

After 3 hours' exposure at 52°C all viability was lost.

(2) *P. triticina*.—Fresh material of this rust collected early in March showing nearly 80% germination suffered a gradual decline from 50% at 32°C to 30% germination at 47°C after 3 hours' treatment.

After 18 hours' exposure at 45°–47°C all viability was lost.

The control kept at a constant temperature of 28°C for 18 hours showed nearly 50% germination.

After 3 hours' exposure at 52°C hardly 2% spores germinated.

(3) *P. graminis*.—Fresh uredospores of this rust collected early in March showing nearly 80% germination suffered a gradual decline from 50% at 32°C to less than 10% after three hours' exposure at 47°C.

After 18 hours' exposure at 47°C all viability was lost.

The control kept for 18 hours at constant temperature of 28°C showed excellent germination—above 70%.

After 3 hours' exposure at 52°C all viability was lost.

It is interesting to note that after the first week of April (the harvest time) uredospores from fields collected even early in the morning showed hardly 5% germination in the case of *P. graminis* and *P. triticina*. The uredospores of *P. glumarum* lose their viability much earlier and by the end of March normally no viable material of this rust is available in fields near Agra.

These data, when considered in the light of the fact that the shade temperature in summer may casually rise up to 117°F at several places in the Indo-Gangetic plain, leave little doubt about the destruction of uredospores and their inability to infect the new crop in October following.

For several hours each day, and day after day, the fields are exposed to bright sun and scorching heat when the temperature is very much higher than the highest used in these experiments.

Again it is impossible to explain why the rusts should not appear soon after our new crop is up in November if any viable uredospores were available on the plains. As pointed out

above, the rusts normally appear after nearly 3 months from the time the crop is sown.

It is only right to conclude, therefore, that in the plains there is no source of infection left from the previous crop.

In this connection it is interesting to quote from an unpublished work of Dr. Burns conducted at the college farm at Poona at an altitude of 1850 feet above sea-level. Dr Burns inoculated some susceptible varieties of wheat with *P. graminis* under the shade of a mango tree in May 1909 and the inoculated plants developed rust after five weeks.

The average temperatures recorded at Poona that year for May and June were as follows:—

			Max.	Min.
May	99·3°	73·5°
June	86·2°	72·0°

Dr. Burns concluded "that given a series of wheat plants two or almost three generations is all that is necessary and the continuance of the rust from season to season in the uredo-stage is assured."

There is no information in this work on the behaviour of the yellow and the brown rusts.

It may be pointed out, that continuance of the black rust as suggested by Dr. Burns is possible provided suitable self-sown plants are available in the shade and when the temperature is not very high. It is difficult to say whether inoculations made by Dr. Burns would have succeeded in the open.

At any rate, this work suggests, the possibility of the survival of uredospores of black rust in shade at an altitude of nearly 2,000 ft. and a temperate climate. It is much more likely, therefore, that at higher altitudes, where the summer is comparatively cool, the uredospores of other rusts also should survive. At Muktesar for instance, uredospores of even the yellow rust, which suffers more from heat than the other two, survive from previous crop on self-sown wheat.

That none of the three rusts can survive the summer heat on the plains of the greater part of this country is a safe conclusion.

From a comparison of the tables given below, it will be clear, that during May–August, the hottest part of the year, the temperature of Agra is easily 20°–30°F. higher than that of Muktesar.

Data of average temperatures for 3 years.

YEARS.		(1) AGRA.								
		1925.			1926.			1927.		
Months.		Max.	Min.	Mean.	Max.	Min.	Mean.	Max.	Min.	Mean.
May	..	105.1°	77.5°	91.3°	102.3°	75.3°	88.8°	105.0°	76.2°	90.6°
June	..	95.7°	79.1°	87.4°	110.1°	84.0°	97.0°	106.0°	82.6°	94.3°
July	..	88.6°	77.7°	83.1°	96.2°	81.2°	88.7°	94.2°	79.4°	86.8°
August	..	94.3°	78.1°	86.2°	90.1°	78.0°	84.1°	88.5°	77.4°	87.9°
Sept.	..	97.5°	73.5°	85.5°	90.0°	73.9°	81.9°	93.0°	72.9°	82.9°
Oct.	..	95.6°	63.7°	79.7°	93.5°	59.4°	76.5°	92.5°	65.0°	78.7°

YEARS.		(2) MUKTESAR.								
		1925.			1926.			1927.		
Months.		Max.	Min.	Mean.	Max.	Min.	Mean.	Max.	Min.	Mean.
May	..	72.7°	56.8°	64.7°	68.5°	54.2°	61.3°	70.0°	54.9°	62.5°
June	..	67.7°	56.8°	62.3°	78.1°	61.9°	70.0°	73.5°	59.7°	66.6°
July	..	67.1°	58.5°	62.8°	70.1°	59.1°	64.6°	69.5°	58.6°	64.1°
August	..	68.1°	58.2°	63.1°	67.4°	58.4°	62.9°	65.9°	57.7°	61.8°
Sept.	..	66.8°	55.1°	60.9°	67.2°	56.4°	61.8°	68.4°	55.8°	62.1°
Oct.	..	64.6°	49.5°	57.1°	64.6°	49.7°	57.1°	63.6°	50.8°	57.2°

That explains why the uredospores of rusts can survive the summer at the latter station.

It is interesting to note, that in the Kumaon hills at places with an altitude of less than 6000 ft. the writer has not so far come across viable uredospores of any of the three rusts during September-October. They may, however, survive during a cooler summer or at places rather protected from direct sun. It is unlikely that yellow rust could survive at such altitudes because it suffers more from heat than the other two.

It is probable that at places as high as Muktesar with more of wheat cultivation and at places higher still a good deal more of viable uredospores may be available during summer months and at the time when the new crop is sown.

CLIMATIC CONDITIONS ON THE PLAINS OF INDIA IN OCTOBER-DECEMBER.

That climatic conditions on the plains of India are favourable, at any rate, for *P. triticina*, will be clear from the fact that wheat seedlings taken in a glass cage and inoculated at Muktesar on October 2nd and brought down to Agra showed uredo-sori after 8 days; and since then the culture of this rust was continued right up to April following in the Botanic garden attached to our laboratory.

The length of the incubation period during October-December varied between 8 and 11 days.

This fact lends further support to the view expressed above, that but for the absence of the source of infection, the brown rust at least, should appear in November on the plains.

INFLUENCE OF WEATHER ON RUST OUTBREAKS.

Butler and Hayman (5) observed that moist cloudy weather in January–March is very favourable for development of rusts. Moreland (15) has quoted data of rainfall and humidity for the districts of Allahabad, Benares and Jhansi for a long period.

His conclusions are: (i) that the amount of rainfall in October is not a determining factor (ii) extent of rust varies generally with the humidity in the months of January and February taken together.

It is a fact, even within the knowledge of the illiterate farmers, that after the winter rains and cloudy weather there is a spontaneous outburst of rusts on their crops.

From the data available from meteorological observations one may safely conclude, that at Agra year after year the humidity of the air in December–February is distinctly higher than in the month of November. The same is true in a general way of the greater part of the area under wheat on the plains.

It is generally during this period that the Indo-Gangetic plain gets a few showers of rain also.

With regard to the direction of prevailing winds it is difficult to come to any definite conclusions from the data available. Winds from the North, North-east, and North-west have been recorded during the months of November–February at the Agra Observatory, during the years 1924–27. One cannot say that no wind-blown uredospores could reach the plains from the Himalayas in November and December. It is unlikely that a large number of uredospores get blown down to the plains during that period in normal years, because of the paucity of material due to intense cold and a longer incubation period up in the hills at that time.

On the whole, during January and February each year, there are more days when the direction of winds is favourable for rust spores to be blown down to the plains than in November and December. For instance in January 1927, there were 19 days out of 31 when the winds were favourable; but in November and December 1926 there were favourable winds only on 9 and 5 days respectively.

It is clear from what has been said above that there are three important factors which one has to reckon with as regards the first outbreak of rusts on the plains:—

(i) Quantity of uredospores available during November–December on the one hand and during January–February on the other, at such places in the hills where they survive during the critical period (summer).

(ii) Direction of winds during the period November–December and January–February.

(iii) Humidity on the plains during the same periods.

It has already been pointed out, that up in the hills the

rust mycelium grows by fits and starts during the period November-January and in years when the winter is comparatively mild the first outbreak in the hills may be earlier.

It may well be argued that in normal years there should be plenty of rust material on the crops in the hills late in December or early in January after an incubation of nearly 2 months.

The rusts having appeared up in the hills, with favourable winds and a higher humidity in the plains, casual showers of rain, and plenty of dew every morning, it is no wonder that the first outbreaks on our crops on the plains appear at places near the hills early in January. At places farther off the first outbreak takes place a few days later. There may be a plant here and there infected about the same time but the epidemic form has invariably been noticed earlier, as has been mentioned above, at places at the base of the hills.

In order to ascertain the first date of the uredospores being blown down to the plains, work with stationary slides and spore traps has already been started. It will also be possible to find out the relative numbers of spores blown down in November-December on the one hand and in January-February on the other.

THE LIFE HISTORIES OF THE THREE RUSTS IN INDIA AS FAR AS KNOWN AT PRESENT.

(1) **YELLOW RUST.**—It is interesting to note that notwithstanding the absence of an alternate host the annual recurrence of this rust is the easiest to explain. Viable uredospores of this rust have been found at Muktesar in September-October several times. It is probable that at places between 7,500 ft.-9,000 ft. (approximately the limit beyond which little wheat is sown) the uredospores of this rust survive throughout summer and infect the new crop each year in October-November. In May 1928 this rust was observed in an epidemic form on wheat in the Simla hills up to Narkunda which is nearly 9,000 ft. above sea level. In the neighbourhood of Simla itself (7,000 ft.) this rust was common on the crop also in March 1928 but during summer and in September-October it was very rare. It has been observed on some wild grasses and except once it has not been found on self-sown plants of wheat in summer or September-October.

It does not need much of an explanation to connect the source of infection surviving from the previous crop with rust outbreaks each year on the new crop at Muktesar and stations which lie between 7,600-9,000 ft. approximately. It is probable that uredospores get blown down to the plains from the hills and start the first outbreaks normally in the month of January, if weather conditions are favourable.

The uredospores of this rust are more resistant to cold than those of the other two as stated before.

Even if an alternate host does exist, which is unlikely and has not been discovered so far, it is doubtful if it plays an important part as the annual recurrence of this rust can satisfactorily be explained without it.

(2) BROWN RUST.—As has already been said in the earlier part of this paper, viable uredospores of this rust are also available in large quantity every year at Muktesar in September–October, so that the infection of the new crop at that locality is easy to explain. Uredospores of this rust have also been collected from Dhari in September–October which is on the way to Muktesar and is nearly 6,000 ft. above sea level. The uredospores of this rust can resist warm weather better than the yellow rust; but are less resistant to cold than the latter.

At Bhimtal, which is 4,400 ft. above sea level, the uredospores of this rust have never been found during the critical period, but considering the incidence of this rust in general, one may expect its uredospores to survive throughout summer under protection at a height of 5,500 ft. or so above sea level.

It is interesting to note in this connection that in March 1928 this rust was altogether absent at Muktesar; although the yellow rust was observed in an epidemic form at that locality at that time. In October, 1927 before the crop was sown both yellow and brown rusts were observed on self-sown plants there.

The absence of this rust at Muktesar in March last may be due either to a longer incubation on account of the cold or the uredospores and the mycelium inside the host got killed by the winter cold. It may also be mentioned that up to an altitude of 5,000 ft. in the Kumaon hills this rust was very common in March, 1928. On the plains it was observed at Haldwani, Bareilly, and Chandausi as early as the middle of January in the same year and by March it was present as a serious epidemic on the plains in U.P.

The source of infection under these circumstances, must have spread from places lower than Muktesar, where the winter was not so severe and where there was little snow.

The spread of this rust, from places where it escapes death by cold, to Muktesar and places similarly situated is not difficult to explain on account of the circulation of winds.

That there are viable spores in the upper air will be clear from the work of Stakman and others (22) who caught spores of *P. graminis*, other rusts and fungi in spore traps during flights in aeroplanes, at an altitude of 1,000–11,000 ft. above the surface of the earth. These authors conclude that "certainly aeciospores and urediniospores (uredospores) are carried up as high as 10,000 feet and more above the surface of the earth."

The life-history of this rust is not yet complete as far as its connection with the aecidial stage on species of *Thalictrum*, is concerned.

As stated above Barclay (1) has recorded that an aecidium on *Thalictrum javanicum* appears in July near Simla. In spite of a careful search at that time of the year this has not been found so far.

In March, 1928 a thorough search was made for the uredospores of this rust in the neighbourhood of Simla and whereas the yellow rust was present in an epidemic form no trace of this was found. Observations were repeated in May, 1928 and even then this rust was absent at Simla, also on the way to Narkunda and at Narkunda itself, although at every place yellow rust was very common. In July and October of the same year in spite of a careful search neither the aecidium on *Thalictrum* nor the uredospores of this rust on self-sown wheat were found at that locality.

It is too early to say that *Thalictrum* is not a host for this rust.

Aecidium on *Thalictrum* was collected by Professor Kashyap in July, 1922 at Kuti (13,000 ft.) in the Kumaon hills, and it is likely that it may be found at lower altitudes also where wheat is cultivated. It may be possible, later on, to solve the connection between this rust and *Thalictrum*, but even if *Thalictrum* be a normal alternate host the occurrence of aecidium on it in July or August would be of little use for infection of wheat crop because it is harvested long before that.

Diseased *Thalictrum* can only be a source of infection for whatever self-sown plants there may be in July-August and that is quite likely.

The probable source of infection as far as one can see are the surviving uredospores from previous crop.

(3) BLACK RUST.—The connection between the aecidial stage on species of *Berberis* found in the Himalayas and the black rust on wheat is still under investigation, and it is premature to make any definite statements on this point.

It is interesting to note however, that on several occasions this rust has been observed on the wheat crop on the plains, earlier than the aecidial stage on barberry in the hills.

In the year 1928 this rust was observed at Chandausi on the crop as early as the middle of January. That was the only time when so early an attack of this rust was observed on the plains. Normally it appears by the middle of February each year.

The aecidial stage on species of *Berberis* has not been found near Simla before March and then too it is not common.

From Kathgodam, which is at the base of the Kumaon hills, up to 5 miles to an altitude of 4000 ft. this rust was found in an epidemic form in the middle of March, 1928. At Bhimtal, 4500 ft., it had just appeared in the vicinity of rusted bushes of *Berberis aristata*.

Above 5000 ft. and up to 7600 ft. (Muktesar) no trace of

this rust was available on the wheat crop, but infection on bushes of barberry was common in March, 1928.

At Simla it was absent in March, 1928 and aecidial stage on *Berberis* was rather rare. This rust was observed later on wheat in May, 1928 at Simla in some fields in the vicinity of infected bushes of *Berberis*. Beyond Simla and up to Narkunda (9000 ft.) there was no trace of this rust even so late in the season as the month of May. Uredospores of this rust on self-sown plants were observed only once near Simla in July, 1926.

In the Kumaon hills, at places that have been visited so far, no uredospores of this rust on self-sown wheat have been found in September–October.

Another fact which has an important bearing on this question is the occurrence of plenty of aecidial material on species of *Berberis* in July–October. Inoculations with that material made on wheat at the spot have so far yielded only negative results. Consequently, one cannot conclude that the aecidial stage, so common on species of *Berberis*, is connected with the rust on wheat.

In view of the rigid specialization between this rust on wheat and one on wild grasses it is quite likely that the material used for inoculations was not connected with the wheat-rust. Further work on this aspect may lead to a definite conclusion.

The occurrence of this rust on wheat crop in the hills in March–May in the vicinity of diseased bushes of barberry could not be without significance.

It is too early to say that barberry has nothing to do with this rust. On the contrary it is probable that it is an alternate host, only our experiments have not hit the right material yet.

At any rate, it is certain, that the outbreak of this rust on the plains has nothing to do with the aecidial stage on barberry occurring in March–April because the disease on the plains has been observed as early as the middle of January.

If rusted barberry is the source of infection of wheat, it is the aecidial stage found in July–October, which could only infect self-sown plants of wheat and produce the uredospores on them. So that, as far as the plains are concerned, fresh outbreaks of this rust are due to such, uredospores that survive from the previous crop in the hills, or those that appear on self-sown plants as a result of infection from rusted barberry in July–October.

As far as hill stations with a milder winter are concerned a second source of infection may be the aecidial stage that first appears on barberry in March–April.

At higher altitudes the probable source of infection is the aecidial stage on barberry appearing in March–May because the uredospores from previous crop can not live through the

intensely cold winter. This, if finally established, will correspond to the life-history of this fungus in Europe, U.S. America, etc.

Such uredospores that survive from previous crop may infect the new crop in the hills in October–November and may be blown down to the plains in January–February from places with a milder climate.

There is little likelihood of the survival of uredospores of this rust at such places in the hills where there is plenty of snow and consequently a severe winter. Survival of the uredospores of this rust during winter is possible only at places with a milder weather.

Uredospores of this rust are more resistant to heat than those of yellow and for that reason their survival is possible even at an altitude of 4000–5000 ft. Reference may be made again to Burns's work which mentions their survival at Poona (1850 ft. above sea level) under the shade of a mango tree during summer.

DAMAGE DONE BY THE THREE RUSTS PUT TOGETHER TO THE WHEAT CROP IN INDIA.

Butler (3) stated that "probably Rs. 4,00,00,000 is not above the annual loss to India" due to these pests.

Barclay (1) observed "that the number of grains from rusted plants that were found to be equal in weight to ten healthy seeds of wheat varied from 20 to 90."

The total loss as one would expect may vary from year to year but the figure quoted above will show clearly how enormous is the damage caused by these parasites to one of the most important crops of our country.

MEANS OF COMBATING RUSTS ON WHEAT IN INDIA.

For want of space I do not propose to say much on the breeding of rust-resistant varieties of wheat and their cultivation in preference to other varieties. This indirect method of combating rusts has given satisfactory results.

That the breeding of rust-resistant varieties of wheat has its own complications, will be clear from the work of Miss Newton (16) Stakman and Piemeisel (21) and others who have drawn our attention to the occurrence of several "biologic forms" under *P. graminis tritici*. Miss Newton has recorded the occurrence of fourteen biologic forms of *P. graminis tritici* (the wheat stemrust) in Canada.

It is too early at this stage, to talk of adopting measures of direct control of the spread of infection to our wheat crop on the plains. For this purpose, it would be useful to prepare a list, based on actual observations extending over a number of years, of all stations in the area of wheat cultivation where normally the uredospores survive during summer.

It will be clear from what has been said above that :—

- (i) As far as the plains are concerned rusts on wheat normally occur only for a period of three months or so each year.
- (ii) That the uredospores from previous crop are killed by the heat of summer on the plains and that there is no source of infection on our fields when the new crop is sown.
- (iii) That leaving alone the details of the life-history of each, the foci of infection in the case of all the three rusts lie in the hills.
- (iv) That by far the most important factor, in the recurrence of these rusts in general, is the survival of uredospores from the previous crop that live through the critical period (summer) on self-sown plants and tillers in the hills, where climatic conditions are more favourable.

In view of the above facts, the destruction of self-sown plants that occur after harvest on the fields along the hedges and anywhere in the neighbourhood is likely to check the disease to a considerable extent.

This direct method of combating rusts should be effective only when every cultivator destroys the self-sown plants and tillers with fire.

In view of the absence of local sources of infection on the plains, and on account of long distances between the area under wheat on the plains and comparatively few places in the hills where uredospores definitely live during summer, the problem of combating rusts in this country offers a unique opportunity for direct control.

The work under report further suggests, the possibility of tackling this problem, by stopping the cultivation of this crop in the hills for two or three years, except at places at lower altitudes where uredospores are normally killed by the summer heat.

It is difficult at present to tell in rupees, annas, and pies the cost of the destruction of infected self-sown plants, and it is still more difficult to estimate the depreciation in the total yield if cultivation of wheat were suspended for two or three years in the hills.

From the information, which some of the Provincial Departments of Agriculture have kindly supplied to me, I find that the area under wheat in the hills, where survival of uredospores is probable, roughly lies between 2–3% of the total area under wheat in this country.

¹ Suspension of the cultivation of wheat for two or three

¹ NOTE. What has been said about measures of control for wheat rusts applies to rusts on barley also. Study of rusts on barley has been

years at places in the hills, where there is a possibility of the survival of uredospores, and the destruction of self-sown plants, will mostly eradicate the sources of infection and will also protect the crop on the plains against indirect infection by brown and black rusts from their suspected alternate hosts, if any. The yellow rust is likely to be the first to disappear by this treatment as it has no alternate host.

It should be practicable to cultivate oats instead at such places because so far no rusts on oats have been recorded from this country.

CONCLUSION.

Howard and Howard (9) observed that : "The propagation of the wheat rusts of India from season to season is therefore still an unsettled problem and it is hoped that further investigations will clear up the question. As soon as we know with precision the course of the life-histories of the Indian wheat rusts between the harvesting and the sowing periods, it will then be possible to consider how far rust can be checked by direct means."

The work under report tells us the course of the life-histories of rusts between the harvesting and the sowing periods and the solution of the wheat rust problem in India too is well within sight. The sources of infection having been located, it may be possible, a few years hence, to take practical steps for direct control of the spread of infection to the wheat crop in the hills and save the crop on the plains thereby.

So far the work has been more or less restricted to the United Provinces of Agra and Oudh which is an important wheat growing area. Outside U.P. parts of the Simla hills have often been visited.

The nature of the problem demands first hand information about other provinces also where wheat is cultivated. It is contemplated to extend the work gradually to other places in the Punjab, Central Provinces, Rajputana, Bihar and Orissa, Baluchistan, and Kashmir.

For further knowledge on the life-histories of brown and black rusts, there is need for extensive experimental work in the hills. Besides it would be useful, for work on breeding of resistant varieties of wheat, that culture work on these rusts be conducted in the hills for two or three years, with a view to find out if there are any "biologic forms" of these rusts in this country also.

That kind of work is impossible on the plains because the

conducted simultaneously with those on wheat but for want of space the details of this work had to be left out and will be published as separate note.

rusts live on our crops only for three months or so each year and by the time a pure culture is established the hot weather sets in and the culture is killed.

I feel, that the progress of this work has been rather slow on account of difficulties peculiar to the problem under report.

The work involves heavy expense in travelling and several visits have to be paid to each place under observation at different times of the year. I believe it is no exaggeration to state that these investigations are far too expensive for a private individual, and I have already spent a large sum of money from my own pocket in connection with this work.

I realised it long ago, that the work should be subsidized by the Central Department of Agriculture, which was approached more than once, but no grant-in-aid for this work has so far been made.

I shall conclude by saying, that several countries on the continent of Europe have solved their problem of cereal rusts. There is considerable work being done in Canada and the United States of America are spending huge sums of money over the eradication of barberry to save their cereal crops.

It is discouraging to find, that the Government of this country should be unable to subsidize work on this problem which has been in progress for over 5 years already.

We know so little as yet, about the pests under report, but we are certainly nearer the solution of this problem to-day, knowing as we do, the location of the sources of infection for our wheat crop.

The first stage having been covered, I hope before long, it would be possible to save the greater part of the 4 crores of rupees which our poor agriculturists lose each year, in the form of damage done by these rusts.

Before I close, I wish to express my warmest thanks to Mr. Babu Lal Gupta, M.Sc., once my student and now a colleague, for the assistance he has given me in this work.

SUMMARY.

A detailed study of the incidence of the three rusts on wheat and barley has been made for a period of over 5 years and the work suggests definitely that about the harvest time very little of the viable material of uredospores is available in the Indo-Gangetic plain.

Details of work on the rusts of barley have been left out for want of space.

It is almost impossible for the uredospores to survive the intense heat of summer in the plains of the greater part of India, where the maximum temperature in shade may be well above 110° F. for several weeks.

At the time when the wheat crop is sown, from the last

week of October to the middle of November, no local source of infection is available in the plains as a whole.

Conditions in the hills are different and viable uredospores of yellow and brown rusts have been discovered on self sown plants and tillers near Muktesar in the Kumaon hills at an altitude of 7600 ft. above sea level in September-October, several times.

YELLOW RUST.

The occurrence of viable uredospores of this rust on self-sown plants and tillers at a time when the wheat crop is sown at places like Muktesar, clearly suggests that the factor of outstanding importance in the recurrence of this rust, in the hills, is the survival of uredospores from previous crop during summer (critical period). The infection of the new crop by uredospores from self-sown plants, occurring within a few feet of the fields under cultivation, does not need much of an explanation.

Following a successful infection of the new crop late in October or early in November, there is a long period of incubation (longer than the normal 7-10 days in favourable weather) on account of a fairly cold weather at that altitude after which the rust appears in the uredo-stage.

The exact dates of this first appearance is impossible to predict and may vary from year to year according to the conditions of weather.

Normally, the first outbreak of this rust may be expected in the latter half of December at Muktesar and at places similarly situated where wheat is cultivated.

It is interesting to note, that in spite of the absence of any host suspected to bear the æcidial stage of this rust, its recurrence is the easiest to explain.

Observations on the incidence of this rust at Muktesar suggest in a general way, a striking similarity to what the writer has recorded in a previous publication, about the neighbourhood of Cambridge.

It is probable that the outbreak of this rust on the wheat crop at Muktesar and places similarly situated leads to rust outbreaks on the plains due to wind-blown uredospores.

Year after year, the crop at the base of the Kumaon hills gets infected earlier than at places farther off.

BROWN AND BLACK RUSTS.

No connection between these two rusts and their suspected alternate hosts, species of *Thalictrum* and *Berberis* respectively, has so far been established and their life-histories are under investigation.

On the basis of work done so far, it seems probable that

uredospores surviving from previous crop play an important part.

Both these rusts were found on the crop in the plains as early as the middle of January in 1928. Normally the brown rust appears early in February and the black a few days later.

The ædial stage on *Thalictrum* is said to appear in July-August and the ædial stage on *Berberis* in August.

It will be clear from this that even if *Thalictrum* and *Berberis* ultimately prove to be normal alternate hosts for brown and black rusts respectively, they are of no account as far as the infection of the wheat crop in the plains is concerned.

It is likely however, that the ædial stages on *Thalictrum* and *Berberis* may infect the self-sown plants of wheat available in July-August in the hills, and the uredo stage so produced may live till the crop is sown in October-November.

The new crop gets infected wherever such uredospores are available. At places with a severe winter and snow (like Muktesar) it seems probable that both uredospores and mycelium inside the host plants get killed. It is certain that at that altitude the black rust cannot overwinter.

The uredospores as well as the mycelium may, however, survive and produce the first outbreak in December-January at places with a lower altitude, where the winter is rather mild. Such outbreaks may lead through wind-blown uredospores, to infection of wheat on the plains in the month of January.

The occurrence of black rust on wheat in the neighbourhood of Simla and Bhimtal and so close to infected bushes of barberry suggests a similarity to the life-history of this rust in European countries and U. S. America. As stated before, one cannot be definite about this connection till successful infection of wheat has been brought about by inoculations with the æcidiospores from barberry. So far the results have been negative.

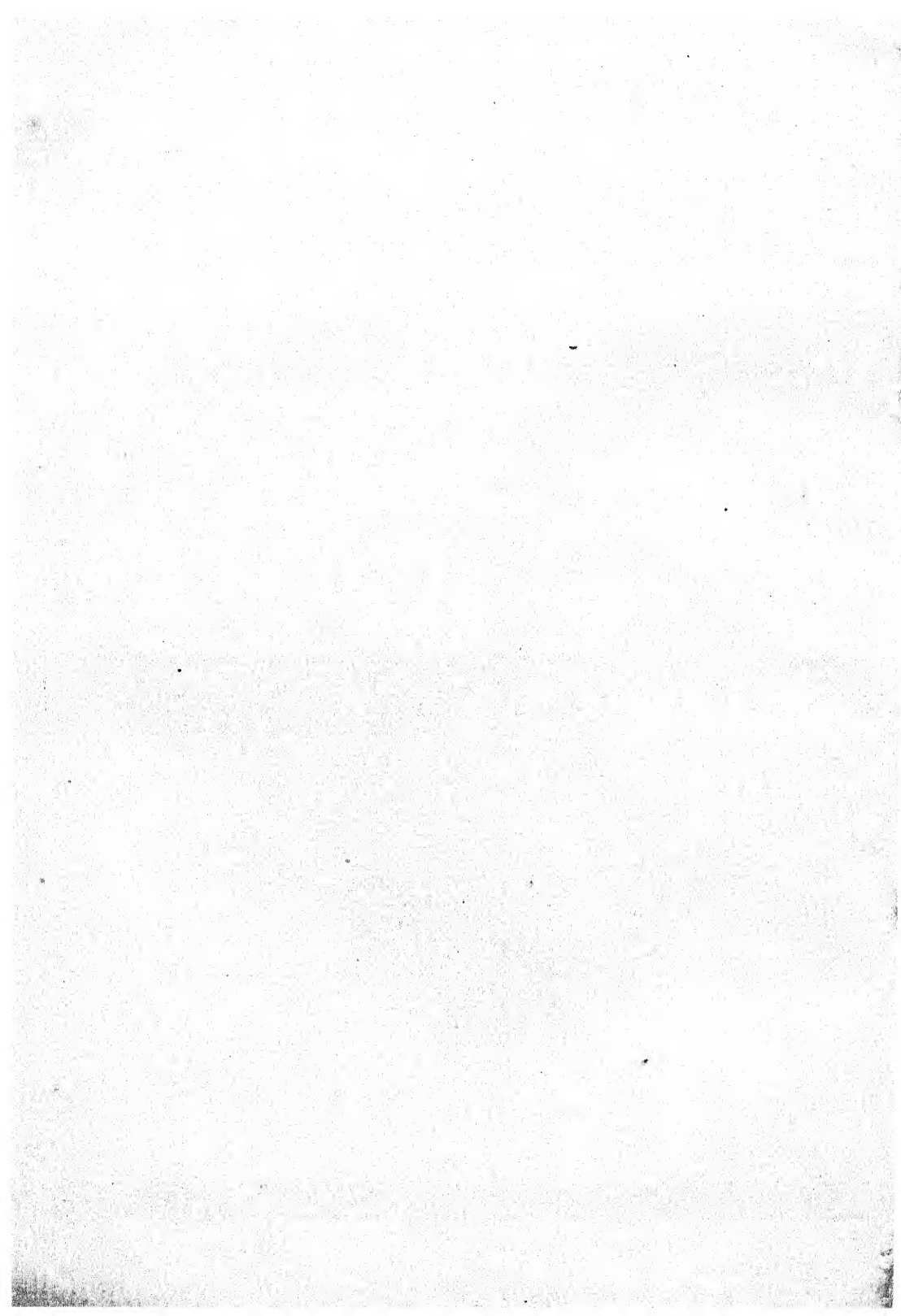
The work conducted so far clearly indicates, that the source of danger to our wheat crop lies in the hills and that there is a pressing need for further investigations on this problem.

The absence of a local source of infection (viable uredospores or infected alternate hosts) on the plains at the time when the crop is sown, offers a unique opportunity for direct measures of control of these pests in this country.

The work further suggests, that the measures of control lie in the destruction of self-sown plants and tillers after harvest in the hills. Still more effective would be, the suspension of the cultivation of wheat for two or three years at such places in the hills where uredospores can survive the summer heat.

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Section of Botany.

Abstracts.

1. Germination and seedling anatomy of *Ephedra foliata* Boiss. and Kotschy (= *E. peduncularis* Boiss.).

RANBIR LAL CHOPRA, Lahore.

The seeds of *E. foliata* are roughly triangular, compressed and flattened on their adaxial sides, but rounded abaxially with a distinct midrib. The hard, dark brown testa shows a number of processes abutting against the long and narrow micropylar tube formed by the inner thin papery layer. The dicotyledonous embryo is embedded within the pale-yellow endosperm. On germination the hypocotyl along with a part of the cotyledons forms an arch. The linear cotyledons are epigeal, and at first act as the absorbing organs and finally form the first green leaves.

The root is diarch and protostelic below. It becomes siphonostelic above. The poorly developed phloem is in four patches. The two xylem bundles of the root pass up into the hypocotyl. The metaxylem of each bundle gradually splits and the two split halves move towards the outside. Ultimately, the protoxylems of the two bundles split into two each, thus resulting in two pairs of collateral endarch bundles. Higher up a mass of meristematic cells with tracheides appears between the opposing bundles, from which four plumular bundles are formed, a pair of which finally passes into each of the first pair of leaves. A pair of hypocotyledonary bundles passes into each cotyledon and remains unbranched to its tip. The protoxylem groups of the two collateral endarch bundles of the cotyledon face each other. The transition phenomena in the seedlings afford but little assistance in the delimiting of species within the genus.

2. A study of *Dumortiera*.

SHIV RAM KASHYAP and L. BRIJ LAL SETHI, Lahore.

Specimens of *Dumortiera* have been examined from six different places in Tehri Garhwal between 4000 ft. and 7000 ft. above sea level, from Mussooria, Simla, Ranikhet, Kulu, Chamba Valley, and two places in South India.

It has been found that the plant is exceedingly variable in all the characters which have been used for delimiting the species. Scales on one occasion were met with which divided into two plates folded one on the other like the dorsilateral leaves of some of the leafy Jungermanniales. Transitional forms occur between the smooth and tuberculate rhizoids, the former often containing fungi. There is often a mycorrhizal region in the thallus but it is absent in the plants growing actually under water. Plants vary as regards the presence of papillate cells on the dorsal surface and the air-chambers behind the apex, even in the same locality growing a few feet away from each other. Generally papillate cells are abundant and air-chambers well developed in plants growing in comparatively dry places and they are absent in plants under water. The surface may be densely velvety or entirely smooth with all intervening grades and a branch from a perfectly smooth thallus may show reticulations on its dorsal surface. Papillate cells are not found on the floor of the air chambers. The apex often goes on growing after producing a receptacle.

Female receptacles are always papillate on the upper surface even when the thallus is smooth. The configuration of the receptacle is variable. The male receptacle is rounded or lobed and has very few bristles or none in the young condition but later on develops bristles on the margin. The stalk of the receptacle has no air chambers or papillate cells. It has two grooves anteriorly. The development of the sex organs and the embryo is the same as described by other writers. Spores are $22\ \mu$ — $26\ \mu$ in diameter. Small elater like cells mostly unispiral, sometimes tri- and quadrispiral are found fixed at the bottom of the capsule.

Some of them are trumpet shaped. Unispiral pen-shaped elater-like cells $26\ \mu \times 12\ \mu$ and trumpet-shaped ones $60\ \mu$ — $100\ \mu$.

The conclusion is that there is only one species of the genus *Dumortiera*, showing variations on account of the differences in habitat, specially the amount of water. The species may be called by earliest name *Dumortiera hirsuta*.

3. A morphological and anatomical study of *Ephedra foliata* Boiss. and Kotschy (= *E. peduncularis* Boiss.) and *E. distachya* Linn. (= *E. vulgaris* Rich.).

RANBIR LAL CHOPRA, Lahore.

Ephedra foliata is a straggling shrub, generally climbing, found in the "rakhs" near Faridkot and Chhanga Manga (Punjab). The leaves are in pairs in the young plants and in whorls of three in the adult specimens. Each leaf is filiform with a sheathing base. More than one branch may arise apparently in the axil of a leaf both in the vegetative and reproductive regions on account of the suppression of the first internode. *E. distachya* is a low, rigid, tufted, erect shrub with a pair of connate, scale-like sheathing leaves at a node, found on higher levels between 7,000 and 12,000 ft. in the Himalayas.

The primary root is simple and diarch. The secondary root possesses the following interesting features:—(1) it is rich in secondary wood consisting of tracheides with both the abietinean and araucarian types of circular pits on the tangential and lateral walls, bars of Sanio, and tertiary spirals; (2) transitional stages between tracheides and vessels; (3) abundant wood parenchyma; (4) multiseriate composite wood rays consisting of radial bands of parenchyma and elements of the wood; (5) poorly developed phloem.

In the stems of *E. foliata* the pith is parenchymatous with occasional patches of lignified cells near the vascular bundles and a peridermal diaphragm at the base of each internode. In old stems there are three pairs of large bundles alternating regularly with three groups of three bundles each, whilst in young stems only two pairs of large bundles alternate with two pairs of small bundles. The cortical cells are rich in chlorophyll and the numerous sunken stomata are confined to furrows. The stem may reach a thickness of 4 or 5 inches in diameter. In the stems of *E. distachya* the pith cells contain a hard brown substance. Two pairs of large bundles alternating with 2 groups of 3 small bundles each, are found in the lower region of the main stem while in the upper regions there are 3 pairs of large bundles alternating with 3 pairs of small bundles. In lateral branches 3 pairs of large bundles alternate with 3 groups of small bundles, two of which are paired while the third one consists of 3 bundles. The secondary wood of stem is almost like that of root with few differences in detail.

The endarch double leaf trace originates directly from the small internodal bundles of the nodal wood girdle and extends without fusion to the base of the leaf. The intercalary bundle of the other species is totally absent.

In the true foliage leaves of *E. foliata* the palisade tissue is not differentiated in the leaf sheath region; it is developed on the dorsal side

higher up and finally near the distal end it is present all round. The air spaces in the mesophyll increase in size from below upwards. The cuticle is thick and the stomata are sunken. The 2 collateral endarch vascular bundles run unbranched throughout the length of the leaf.

E. foliata is strictly dioecious and the compound strobili strictly unisexual with monosporangiate flowers. The male strobilus has the usual structure as found in other species but the female strobilus is generally made up of four pairs of decussate fused bracts which form cupules, the innermost protecting the ovules. Each strobilus may contain three ovules, but two is the normal number. Commonly one ovule of the biovulate strobili is reduced and vestigial. Each normal triangular ovule has three vascular bundles in its three angles. The ripe fruit has persistent white fleshy and succulent bracts. The investigation is still in progress.

4. A new species of *Senecio*.

C. TADULINGAM and K. CHERIYAN JACOB, Coimbatore.

This species is closely allied to *Senecio corymbosus* Wall, but differs from it in the hoary tomentum of the leaves below, leaves rounded or cuneate at base, involucre bracts 5 and florets 5.

Collected from the Tinnevely Hills between Netterikkal to Sengalateri at an elevation of about 3,000 feet.

The authors name it after Mr. R. D. Anstead, M.A., C.I.E., who has made valuable contributions to the Madras Herbarium.

5. The characters of the cotton boll in relation to its flowering period and position on the plant.

S. N. VENKATARAMAN, Coimbatore.

A daily record was made of the position of each flower on the plant in the progeny of a pure strain of Uppam cotton (*G. herbaceum*), and bolls developing from these flowers were examined for some characters.

Judged in relation to their dates of flowering, bolls were found more or less to decline in the maturation period, seed weight, lint length, and lint weight, towards the later part of the season.

A similar tendency towards later positions was also noted (1) from branch to branch whether sympodial or monopodial along the main stem and (2) from node to node likewise of each branch.

A study of the first node bolls of fruiting branches in relation to their dates of flower opening and height in nodes on the plant of boll revealed that the characters followed the same course of decline along the nodes of the main stem, as was indicated in respect of the flowering period.

Besides the changes above noted, a further variation occurred between sympodial and monopodial branches and independent of flowering period, tending to greater lint and seed weights of sympodial bolls. They were generally better than the monopodials in all the four characters while in lint weight and seed weight they showed superiority to monopodials even of the same age.

The maturation period of bolls was found to decrease with rise of maximum temperature and *vice versa*. With but a few exceptions the Uppam cotton season is one of gradually increasing temperature, and a general fall in the maturation period is the result. The reduced maturation period whether from season to season, or in different parts of the same season, is usually accompanied by a decline in character.

Spinning tests show that the earliest picked cotton is decidedly superior in yarn strength to the late pickings from the same field of a pure strain and is suitable for a higher standard of warp counts.

6. A wilt of *Zinnia* caused by *Sclerotium Rolfsii*.

T. S. RAMAKRISHNAN, Coimbatore.

Sclerotium Rolfsii was observed to cause a wilting of grown up *Zinnia* plants. The fungus was isolated from diseased specimens and infection experiments proved its parasitism on *Zinnia* resulting in the damping off of seedlings and wilting of grown up plants.

It grows luxuriantly on artificial media producing a whitish mycelium spreading out in a fanlike manner and forming in seven days numerous dark brown rounded sclerotia which measure on an average 1.5 to 1.7 mm. in diameter. During its growth the fungus increases the acidity of the medium by the production of oxalic acid. The size of the sclerotium varies to a slight extent with the medium on which it is formed.

Sclerotia have been found to retain their viability for 13 months. They are killed when exposed to dry heat at 55°C for one hour. They die when immersed in 5% solutions of Germisan and Uspulun and 2% of mercuric chloride for one hour. In 2% formalin they are killed in 1½ hours. Many of the sclerotia do not germinate when left on the surface of the soil or one inch below or buried below seven inches.

7. Teratological branching of the thalamus of a species of *Hibiscus*.

S. C. BANERJI, Calcutta.

A plant of *Hibiscus rosa-sinensis* bears sterile double flowers, straw yellow or pale pink in colour. The double nature is due to a branching of the thalamus above the calyx into five arms at the axil of the main petals, and to the petaloid transformation of the stamens. The first internode of the thalamus is developed in the form of a disc and has an articulation at the second node, from which the upper portion of the thalamus with the petals and branches sharply breaks away from the lower, leaving the pedicel, epicalyx, calyx and the disc, in one piece. The pistil is ineffective. The style is undeveloped or develops into a tubular infundibuliform foliaceous body with a five-lobed limb, like a corolla, bearing five dummy stigmas. Another similar or dissimilar, structure grows out concentrically inside the styler tube. There are a few stamens growing up from out-side its base, representing the staminal tube of the normal form.

The arms bear at their summit rudimentary foliaceous bodies for stigmas, and a few antheriferous foliaceous scales, or ordinary stamens. The inference of branching is based on anatomical evidence.

8. A note on the ecology of the flora of Sind.

T. S. SABNIS, Cawnpore.

The flora of the western portion of Sind is influenced by the western deserts. The eastern portion is a continuation of the Rajputana desert.

The flora of the whole of Sind Desert will in course of time assume western characters.

The vegetation includes the following formations:—

- (1) Halophytic or Semi-halophytic; (2) Aquatic or Semi-aquatic;
- (3) Kalar soil; (4) Sand; (5) Gravel; (6) Rock; and (7) Ruderal.

The Laki range near Sehwan is botanically and geologically very interesting.

The flora of these hills is very rich and forms about 1/3 of the whole flora.

Many plants of western deserts have established themselves on these hills.

9. Some observations on the anatomy and biology of the aerial adventitious roots of *Vitis quadrangularis* Wall.

K. G. BANERJEE, Calcutta.

A brief botanical description of the root is given. The general anatomy of the aerial root is described, both in its primary and secondary stages.

The root in its primary stage is characterised by a well differentiated endodermis, a 5-8 layered pericycle and a 3-4 layered ephimeral velamen.

In its secondary stage, which begins very early, the cambium originates simultaneously in three different regions of the root. One originates partly in the pericycle and partly in the conjunctive tissue as in all normal dicotyledonous roots. The other originates in the outermost layer of pericycle and produces secondary cortex only, without producing any cork proper till the endodermis is exfoliated with the primary periderm. The third layer originates in the outermost layer of primary cortex immediately below the velamen and produces only cork. Thus the root is very interesting from the point of view of the origin of cambium—a parallel case to which has, perhaps, not been recorded before. A comparative study has also been made of the structure of the aerial roots of the Banyan and *Tinospora cordifolia* Miers, and the differences noted.

Some physiological experiments were performed and the author was successful in getting a vegetative bud developed on a severed root.

As a result he concludes that these roots are produced—

- (i) to increase the surface of absorption;
- (ii) to make it possible for the stem-joints or segments to be independent of each other in matters relating to water supply etc.
- (iii) to perform the subsidiary function of manufacturing food, with the chlorenchyma developed secondarily; and
- (iv) under special circumstances, to act as organs of propagation.

10. Secondary growth in thickness in the roots of *Amorphophallus campanulatus* Bl.

G. P. MAJUMDAR and P. N. GHATAK, Calcutta.

The roots are almost 4 times as thick at the oldest regions as that a little behind the growing apex. This growth in thickness is not due to dilation and enlargement of the individual cells of the parenchymatous ground tissue, that is, as the result of the so called "primary growth in thickness." Here, as is usual in such monocotyledonous roots which undergo a secondary growth in thickness, the meristem arises in the cortical layer just outside the endodermis, but instead of forming secondary vascular tissues it cuts off externally only new cortical cells in regular radial rows. As a result some of the innermost layers of the primary cortex are crushed to accommodate the secondary cortex and the velamen with some outer-most layers of the same tissue are compressed to form a secondary protective covering. Owing to further internal pressure this secondary covering may rupture at certain points and phellogen layer arises at these ruptured places to form the periderm.

Similar secondary growth has been observed in the stilt-roots of Sorghum and maize, and also in the roots of *Canna indica* Linn. The authors have undertaken a comparative study of the roots of Monocoty-

ledons and propose to submit the results of their enquiry at the next meeting of the congress. Illustrated with photomicrographs.

11. Cyperaceae of the neighbourhood of the town of Dacca.

H. K. DATTA, Dacca.

A short description of the climate and soil of the place is given.

The plants, belonging to the family Cyperaceae, are mostly hygrophytes, growing in moist places or in water with the lower portion of their stems submerged. They grow ordinarily in the rainy-season, but in char lands they grow in winter. A short description of each species has been given. There are 38 species, falling under 11 genera.

12. On the identification of timber with special reference to the more important Madras woods.

G. VISWANATHAM.

The method of identifying timber as generally practised at present deserves to be made more scientific, as it is still somewhat empirical. The chief difficulties in the way are the paucity of clue, and the prevalence—in a given genus—of greater variation than in flowers and even leaves, which renders it more difficult to prepare a 'key' for woods than a 'flora' for a given locality. The equipment and preparation of the material for a macroscopic examination are very simple.

The physical properties of the wood such as weight, hardness, colour fluorescence, odour, touch, nature of aqueous and alcoholic extracts are studied first. This is followed by an examination of the gross structure with the eye unaided, and also with a pocket lens (3 to 10 ×); the transverse section gives more clue than the other two faces.

The microscopic examination is often quite enough and sometimes better suited than a microscopic. The latter, however, has to be resorted to now and then and is invaluable for corroboration by comparison with named slides. In the absence of a wood cutting microtome an iron plane of the Stanley type with adjustable iron can give sections thin enough for certain types of wood.

13. The morphology of *Mangifera indica* Linn.

WINFIELD DUDGEON, Allahabad.

The basic floral structure is 5 sepals, 5 petals, 5 stamens, a massive disk, 1 carpel, and 1 basal anatropous ovule with a single massive integument. Sporogenous tissue differentiates late; in the anther it can be distinguished only after the last mitosis producing mother cells, and in the ovule only after several layers of wall cells have been formed. The life history follows the typical course for angiosperms.

One stamen appears precociously, and usually develops normally. The other four usually fail to differentiate sporogenous tissue, and remain abortive, or occasionally one or two may produce a few mother cells, which may even undergo reduction, but further development is rare.

Degeneration is the rule in the carpel. It may begin as early as the megaspore mother cell, when the entire ovule and ovary are involved; or during embryosac development, when the ovule does not reach full size but the carpel appears normal; or the completed embryosac may degenerate in an otherwise normal ovule.

As a result of these degenerative processes, only a few flowers develop physiologically bisexual, and can produce fruits. These perfect flowers usually are terminal on branches, especially toward the apex of the inflorescence. Lateral flowers are physiologically staminate. Towards the

close of the blooming period the flowers are often completely sterile, and often fall before opening.

The cause of these degenerations may be disturbances in water or food relations due to climatic conditions, or they may be hereditary tendencies working toward decline.

14. A comparative study of certain species included in the Section *Discolor* of the Genus *Fusarium*.

JULIAN H. MITTER, Allahabad.

All the strains except P and P₁ are of the nonstaling type and their growth-rate is not greatly affected by diluting the standard medium.

Septation is considerably affected by diluting the standard medium. CJ is exceptional in showing little change in septation throughout the dilution series. T shows the greatest change. Septation is affected by time in those strains in which (1) the spores take some time to form their first complement of septa (2) degenerative processes set in after the spores are mature. The *Discolor* strains vary with regard to the way in which they react to the time effect in relation to septation. As with the strains studied by Brown and Horne, an optimum curve for septation may be obtained with all the *Discolor* strains with gradients descending in the direction of a high and low concentration of the medium.

The strains SG, D, Pp, L, and T are incapable of forming typical spores at 8G and higher glucose concentrations. With the strains P, Pl, Sa and SB, spores are few at 8G or when present the average septation is low. The strains CC, CB, and CJ are able to form spores up to 18G, but while with CC and CB there is a gradual fall in septation from 2G to 18G, CJ maintains a high 5 mode throughout the glucose series, spores, however, being extremely rare at 20G. The effect of the time factor is felt only in those cases where spore formation is retarded at high glucose concentration or where degeneration processes set in. The effect of an increased glucose concentration on the nature of the spores themselves is seen in the development of granularity in the spore contents. Chlamydospore formation does not appear to be markedly affected by altering the glucose content of the standard medium.

It may be stated as a general rule for all the *Discolor* strains that when the variation in the asparagin content covers a sufficiently wide range, the change in the average septation may be represented by a curve of the optimum type. At 1A and 2A the spores of most of the *Discolor* strains are highly granular. The strains differ widely with regard to the amount of atrophy present at a given asparagin concentration. The majority of the strains produce strong coloration on the asparagin series.

When grown on the acid alkaline series (Ac. 1. 5-neutral-Al 1.0) the strains P, CC, and Sa show the greatest growth at the neutral point. The *Discolor* strains form alkali in media containing asparagin; hence growth is accelerated with time on acid media. Septation is lower towards the alkaline end of the series and it seems probable that the alkali released as a result of the breaking down of asparagin is chiefly responsible for the lowering of septation. The same factor probably causes the maximum colour intensity to pass with time to the acid end of the series.

15. Some fresh-water Algae of Malay peninsula.

KALIPADA BISWAS, Calcutta.

Opportunity for studying the Algal flora of Malay peninsula especially the Federated Malay States and neighbouring localities has been

afforded to me by Mr. Cedric Dover and Miss Mercy Heynes Wood (now Mrs. Dover), who was associated with her husband in making collection from the hot springs area of Kuala Lumpur, while Mr. Dover was investigating the aquatic Rhynchota.

The total number of species recorded in this paper is fifty-eight. Of these the Desmids represent the largest number (32 species) about 55.5% of the total number. Oscillatoriaceae and Coelastraceae are also well represented. Although the number of species found in the collection is not very large, yet it is valuable in comprising four species, five varieties and three forms which appear to be new to science.

The new species are :—

Plectonema malayense Biswas; *Closterium striatum* Biswas; *Micrasterias Doverii* Biswas; and *Cosmarium Woodiae* Biswas.

The occurrence of *Closterium Matheuni* Fritsch var. *ventricosa* Fritsch; and African fresh-water species among fresh-water sponges in the Malay Peninsula is of considerable interest.

16. On a peculiar abnormality in the capitula of *Tagetes erecta* L.

B. N. SINHA, Lucknow.

Over a hundred plants of Marigold were observed to bear mostly abnormal capitula. The abnormality consists in the production of 3-15 shoots, each 2.5-10 inches long, most usually from the peripheral region of the discs in between the florets. Such shoots bear the usual normal compound leaves and each ends in a capitulum. Most of these secondary capitula in their turn bear smaller shoots in between the florets but not much overtopping the latter, each terminating in a tertiary capitulum. It is peculiar that some of the secondary capitula are composed of only 2-6 florets, most of them being sterile. In general, the bracts to the florets in both the primary and secondary capitula are pinnate. In two cases, some of the pinnae of the leaves borne on the secondary peduncle, had become petaloid (yellow) so that they looked exactly like the petals of the ordinary florets. In several cases, fasciation of florets (a homologue of two florets), has been noted. Increase in the number of the floral parts, specially the petals, is very common.

17. On the anatomy of the tubers of *Riccia discolor*.

B. N. SINHA, Lucknow.

Riccia discolor is a very interesting type already described by Prof. Kashyap to bear perennating tubers. These are almost always borne at the growing apices of the thallus to which they are connected by a neck of tissue. The tuber grows vertically downwards and is an elongated club-shaped body. Its outside is covered with numerous long unicellular rhizoids. Near-about the apex of the tuber, there is a deep depression in which the growing point lies protected till the approach of favourable conditions.

18. Microsporogenesis in *Raphanus sativus* L.

R. N. SUTARIA, Ahmedabad.

The pollen mother-cells are distinctly polygonal in outline. There is a delicate granular reticulum in the resting nucleus. The change from the resting nucleus to synizesis is very rapid. No other stage is more clear and prominent than the diakinesis which shows nine distinct bivalent chromosomes. The heterotypic anaphase gives some good counts of 9 univalent chromosomes. In telophase, each pole shows a compact mass of fused chromosomes.

No interkinesis stage was observed and the second meiotic division follows very quickly. The mother-cell wall shows a spine-like projection on one side throughout the homeotypic division. Quadripartition of the pollen mother-cells takes place by furrowing.

19. Some further observations and experiments on the rust on *Launaea asplenifolia* D.C.

SALIG RAM SUD and KANHAIYA LAL, Agra.

This paper deals with some further observations and experiments made on *Puccinia Butleri*, a parasite on the wild herb *Launaea asplenifolia*. After a brief introduction, the paper is divided into two parts.

In the first part a description is given, with a table of experiments on the inoculations of healthy plants with both uredo and aecidio-spores taken from the diseased plants of the same species. The results of these inoculations which invariably ended in the production of uredo sori in both cases, are discussed in relation to the autoecious nature of the fungus. The effect of temperature on the incubation period of both kinds of spores is shown. A few data are also given as to the relation between temperature and viability of the spores, and also regarding the specialisation between different species of the host.

The second part consists of observations made on the probable sequence of various spore forms of the fungus. These observations were first made on diseased plants growing in fields, and then confirmed by those made on the inoculated plants. On the basis of these observations a distinction has been made between the primary and secondary aecidio-spores.

A few remarks are made on the probable connection between the habit of the host with different spore stages of the parasite, and the hibernating mycelium in the root stock of the host. The causes of the fresh infection every year are given in more definite terms.

20. Some observations and experiments on rusts and mildews of wheat and barley.

BABU LAL GUPTA, Agra.

PART I.

(a) INCIDENCE.

Among the three Rusts, the first to appear on the crop in the plains is the Yellow Rust and the last to appear is the Black Rust, the Brown Rust appearing between the two.

(b) YELLOW RUST.

Among the inoculated plants, there has been hitherto, either very weak infection or no infection at all in February and March.

The same varieties of wheat and barley have shown susceptibility and resistance towards local material from fields. That suggests the occurrence in nature of different "biologic forms" of this rust.

(c) BROWN RUST.

From October to December there is a gradual increase in the incubation period which reaches its maximum during December and January. Then again towards February and March the length of the incubation period falls.

The above observations show that the incubation period varies with temperature and that cold has an inhibitory effect on the growth of the mycelium.

(d) BLACK RUST.

As the atmospheric temperature gradually rises during February and March the duration of the incubation period falls.

The rust on wheat attacks both wheat and barley.

PART II.

(a) INCIDENCE AND CULTURE.

Erysiphe has been observed both on wheat and barley crops in the submontane areas only.

Shade and moisture are very favourable conditions for the growth of the Fungus.

Perithecia are formed towards the approach of hot weather.

(b) INCUBATION PERIOD.

Minimum duration of incubation period is in the month of October and maximum in January.

Thus the relation between incubation period and atmospheric temperature is the same as in the case of the Brown Rust.

(c) SOURCE OF INFECTION.

Fresh outbreaks may be due to perithecia which may live through the summer or it may be a case of wind-blown infection from the hills where the disease has been observed on the self-sown plants in October.

21. Observations on the flora of the upper Chandra valley and Spiti.

S. R. KASHYAP, Lahore.

The country, the upper Chandra valley (13,000 ft. to 16,000 ft.) and Spiti were visited last summer. The climate is very cold and dry, and very strong winds are prevalent. In the Chandra valley there are no trees and even small shrubs are very scarce. Fuel has to be taken from lower levels for several days. There is no cultivation above 10,000 ft. In Spiti cultivation extends up to 13,300 ft. and some willow shrubs and trees and some other shrubs are met with. A list of the flowering plants met with is given. *Ephedra vulgaris* is very common, in some places covering large areas. A comprehensive collection of mosses has been obtained and is being worked out. The following liverworts have been found in Spiti:—*Riccia robusta*, *Grimaldia indica*, *Fimbriaria* sp. The following were found in the Chandra valley:—*Riccia robusta*, *Riccia himalayensis*, *Grimaldia indica*, *Sauchia spongiosa*, *Fimbriaria* sp., *Preissia quadrata*, *Marchantia polymorpha*, *Reboulia hemispherica* (doubtful). *Sauchia spongiosa*, which was described by the writer some years ago from one locality only, has been found to be fairly widely distributed on both sides of the middle Himalayas and is very common on the Rotang pass, 14,000 ft. It presents some very interesting features and is being worked out.

22. Some abnormalities in the spike of *Ophioglossum Aichisoni* D'Almeida.

B. R. VASISHT, Lahore.

Plants collected from the Hoshiarpur district, Punjab, showed certain abnormalities. In some cases the spike was divided into two. In other cases the sterile apex of the spike again grew out into a short sporangiferous portions. Details are given. Specimens will be exhibited.

23. Some interesting abnormalities in the cone of *Equisetum debile*.

S. R. KASHYAP, Lahore.

Specimens are described in which the cones show interrupted growth. A typical terminal cone has some sterile leaf whorls below it and a group of sporangiophores again below these whorls. In some cases structures more or less intermediate between the sterile leaf teeth and sporangiophores are met with. Specimens will be exhibited.

24. Studies in seedling anatomy of *Zizyphus jujuba* Lam.
Acacia arabica Willd: and *Vicia faba* L:

BASIR ALI.

1. *Zizyphus jujuba*. Primary structure of root diarch. During transition in the hypocotyl the xylem and phloem bundles divide into two each, the xylem twists and by the shifting of the phloem the typical stem structure, with collateral bundles and endarch xylem, is arrived at. These four bundles divide and form two arc-shaped sets of bundles which give off portions at either end to the cotyledons. Each of the two bundles entering the petiole divides into two and the laterals again divide into two. In the basal laminar portion the centrals divide into two each, and then the two central ones fuse, making the number of bundles odd.

2. *Acacia arabica*. Primary root tetrarch. During transition the xylem splits into four groups, each divides into two, and then the adjacent halves of the different bundles fuse in pairs and twist round. By the shifting of the position of the xylem bundles the typical stem structure is arrived at. The phloem bundles do not divide. The bundles give off a portion each towards the periphery along the major axis. These portions finally fuse, and a single bundle enters the cotyledon. The bundles in the hypocotyl arrange themselves into two arc-shaped sets of smaller bundles. By branching at various levels the mid-rib of the cotyledon gets five bundles.

3. *Vicia faba*. The writer's observations agree with those of Compton, except that the 'triad' going to the cotyledon gives off a branch to the plumule also.

In the first two the lateral bundles in the cotyledon do not fuse with the mid-rib or with each other near the apex but lose themselves in the mesophyll. This is contrary to what is known to be the case in some other plants.

25. A preliminary note on the Indian species of *Caralluma*.

F. H. GRAVELY and P. V. MAYURANATHAN, Madras.

The Indian species of the genus *Caralluma* cannot as a rule be satisfactorily identified from dried specimens, and considerable confusion consequently exists concerning them. The authors now have most of the known species and several new ones growing in Madras. They find them to fall into three clearly defined groups corresponding to the three old genera *Boucerosia*, *Hutchinia*, *Caralluma*, which are now usually regarded as insufficiently distinct for generic rank. Living specimens for growing, or flowers preserved in formalin, would be welcomed for the completion of the work, especially plants from the Punjab.

26. Further work on Golgi Bodies in Higher Fungi.

S. R. BOSE, Calcutta.

Since the appearance of my note on the Golgi Apparatus in Higher Fungi in Nature, London, 3rd December, 1927, we have Prof. Gatenby's

criticisms based mainly on Bowen's work on plant cells in *Zeit. für Zell. und Mikroskop.* Anatomie Band 6 Heft 5-1928. This necessitated further work by way of revision on basidia of higher fungi—some local Agarics and Polypores. Following Bowen's method of fixation in detail (which is really Kolatchev's) small rod-shaped structures (Bowen's "Osmiophilic platelets" which he claims to be present in all plant-cells) equivalent to Golgi bodies are nowhere found within the basidia; the basidia show only a number of round vesicular bodies located at different parts (Figs. 1, 2, and 3). Staining with neutral-red vitally the same spherical bodies appear almost in the same position with the basidia. The results so far obtained confirm my earlier observations that probably the vacuolar bodies in plant-cells represent the Golgi bodies of animal cells.

27. Revival of an old fruit body of *Hexagonia discopoda* Pat. and Hariot, and successful spore-culture from its fresh spore-discharge.

S. R. BOSE, Calcutta.

Hexagonia discopoda is very variable as regards the size of the pores. Lloyd has described forms with three different sizes of pores, some with very small pores, some with medium ones and others with large pores. Starting with spores from the medium-sized one, I have finally come across very small pores within the culture-tubes. A piece of dead branch of *Zizyphus jujuba* Lamk. bearing very old fructifications of *Hexagonia discopoda* was collected from Sodepur, close to Calcutta, in February 1928. Being kept in a moist condition the specimens revived quickly. Within a month and a half a new hymenial surface was formed over the old one and spores were discharged continuously for about a week. Some of the spores were transferred aseptically to sterilised malt-extract-agar tubes where they germinated readily into a soft white cottony growth. Gradually the white mycelial surface showed formation of brownish-black patches which finally deepened, and a porous surface showing very small pores was formed on the side of the glass-tube after a lapse of about a month from the date of the inoculation of the culture-tubes. Subcultures on sterilised wood-blocks within Roux tubes have not fructified, they still persist in vigorous vegetative condition. All the cultures were kept throughout at the ordinary room-temperature exposed to the diffused chamberlight. The porous surface did not show any basidia or basidiospores but only conidia (or secondary spores of Baxter), the pores were remarkably smaller than those of the mother specimen of *H. discopoda*, but the ultimate colouring of the hymenial surface in artificial cultures was practically the same.

28. Insect galls on *Picea Morinda* Link. in Kashmir.

B. SAHNI, Lucknow.

Several years ago the author noticed that in the forests of the Poonch State (adjoining Kashmir) many of the spruce trees bore, at the tips of their vegetative shoots, small woody structures which even a trained botanist, on casual observation, would at once believe to be the female cones of a pine, if he did not know their real nature. As a closer examination conclusively showed, these deceptive structures are really the tips of the vegetative shoots converted into cone-like galls as the result of insect attacks. The galls vary in length up to about 3-4 cm. When fully formed they show superficially a number of rhomboid more or less woody scales fitting together like the scales of a pine cone. From the centre of each rhomboid area projects an acicular process answering to the umbo. This process, however, is sometimes very long and betrays its foliar nature, for it is then exactly like a normal needle-

leaf of *Picea*. The rhomboid scale at the base of each needle is nothing more than the hypertrophied leaf-base, which later becomes woody and closely simulates an ovuliferous scale.

During the months of May, June and July, 1923 the author was fortunate enough to be able to study the development of these galls (and to some extent also of the insects concerned in their formation) while he was spending a vacation at Gulmarg (Kashmir). Here *Picea Morinda* flourishes between the heights of 8-10,000 feet above sea-level, in spite of the fact that most of the trees are infected in the way above described, and some of them are loaded with galls. Oviposition appears to take place early in May, that is, soon after the snow melts away, and the winged insects leave the galls towards the end of July. At this stage the scales gape apart, somewhat in the way that the scales of a seed-bearing cone do to let the seeds out.

Galls of a similar kind are known to occur on *Picea excelsa* in Europe, where different insect species of the genus *Adelges* are concerned in their formation. The Kashmir insects have not yet been identified but an entomologist is being consulted.

In addition to these cone-like galls, the *Picea* trees at Gulmarg bear insect galls of at least two other kinds, which also the author hopes to describe.

29. A bisexual cone of *Picea Morinda* Link.

B. SAHNI, Lucknow.

In another paper communicated to this section the author has said that in certain parts of Kashmir most of the trees of *Picea Morinda* Link. are regularly attacked by insects which convert the tips of the vegetative shoots into galls of various kinds. The abnormal bisexual cone described in the present paper was found in July, 1923 at Gulmarg (8,500 ft. above sea-level) on a large tree bearing hundreds of such galls—a fact suggesting that the abnormality may possibly have something to do with an insect attack on an incipient male or female cone. There is, however, no visible puncture, nor any other apparent sign of association with an insect.

The basal part of the cone bears a number of scales of exactly the same type as the transitional basal scales of a normal female cone. These are followed by a well defined zone of microsporophylls, most of which are well formed and apparently normal. The distal half of the cone is again female, also normal in every respect. The cone is at about the stage of development when pollination takes place, and is about 4 cm. long. Normal pollination in *Picea Morinda* took place at Gulmarg during the week in which the abnormal cone was found.

Bisexual cones have not, so far as the author knows, been recorded in the genus *Picea*, although their occurrence in other conifers, e.g. in *Pinus* and in *Juniperus*, is well known.

30. On the morphology of *Notothylas Levieri* Schiffn. MS.

S. K. PANDE, Lucknow.

Notothylas Levieri is a common liverwort found at several places in the outer Himalayas. The earlier accounts of the species deal only with the structure of the thallus and the mature sporophyte.

The species is interesting on account of the absence of the columella from the sporogonium.

The sporophyte of *Notothylas* has been investigated by several authors and conflicting statements have been made as regards the origin of the archesporial tissue and the nature of the columella. It has been stated by some authors that a columella is present in some capsules while it is absent from others in the same species; and its absence has been variously explained.

The writer has studied in full detail the embryology of *N. indica* Kash. in which a well defined columella is always present. It was therefore thought desirable to study the embryology of a form such as *N. Levieri* in which no columella is found.

The structure and development of the sex organs so far investigated conforms to the usual type found amongst the Anthocerotales.

In the embryology of *N. Levieri* studied so far no trace of a columella has been detected.

31. On the anatomy of certain Selaginellas.

B. N. SINHA, Lucknow.

S. bryopteris (Banda, U.P., and Rajahra, B. and O.): The stele is monostelic and oval but dorsiventral, its upper half being composed of thick-walled tracheides. A trabecular endodermis is not noticeable in comparatively old stems; air-spaces are present in the outer cortex. Rhizophores are probably absent. The root-cortex is lacunar. The leaf-traces in the cortex are surrounded by air-spaces.

S. caulescens (Royal Botanic Gardens, Calcutta): stele elongated and ellipsoidal, monostelic. The leaves have a dorsal lobe which bears a bunch of tooth-like projections. There is a small mucilage cavity (cf. *Lycopodium*) in the dorsal region of the sporophyll.

32. On the occurrence of Entyloma on Selaginella.

T. C. N. SINGH, Indore.

The only case of a fungus (*Acrospermum urceolatum*—a Discomycete) attack on Selaginella seems to have been recorded by Miss Olson in 1897 (Bot. Gaz., XXIII, pp. 367-371). Except for this solitary reference, as far as known to the author, never before was a fungus, specially a Smut, observed to occur on Selaginella. The Selaginella in question is *S. chrysocaulos* from Mussoorie. Externally on the stems and leaves (most usually the latter) of the diseased plants there are dark brown irregular patches formed by the resting spores of the fungus. These spores are of various shapes and they do not occur very deep down in the tissue of the host. They appear to be in a fairly advanced stage of maturation. This is evident from the thick walls and the deep brown contents of the spore. In some favourable cases both the bi-nuclear and the fusion uni-nuclear stages are clearly visible. The nuclei, however, are difficult to see in the mature spores because of their deep brown granular contents.

The species to which this particular Smut belongs is *Entyloma polysporium* (PK) Farl.

The author is indebted to Dr. B. Sahni, who collected the material, and suggested this investigation.

33. On the teratology of certain angiosperms.

T. C. N. SINGH, Indore.

The author describes abnormalities in six different species of flowering plants. (1) *Erythrina indica* Lamk. (Coral Tree): In a flower, an extra standard (vexillum) has been observed in addition to the normal one behind it. It is however interesting to note that the former one is situated slightly displaced from the posterior position. The androecium although monadelphous is formed of only nine (cf. normal ten) stamens of which one is a staminode. (2) *Trifolium alexandrinum* Linn. (Egyptian Clover): The petals, stamens, and gynoecea (but not the sepals) in a very large number of flowers, have become transformed in varying degrees and in various combinations and permutations, into leaves ranging from mono: to tri-foliate ones. In all respects do they resemble ordinary

vegetative leaves except for their smaller size. Anthers, if at all present, are devoid of pollen grains. (3) *Crotalaria juncea* Linn. (Hemp): Fasciation of the stem and peduncle has been observed, but there is no peculiarity in the flowers borne on the latter. In both (4) *Vitis vinifera* L. and (5) *Prunus amygdalus* Baill. a record of the occurrence of double fruits is made. (6) *Mirabilis Jalapa* Linn. (Four O'clock Plant): fasciation of a leaf—a homologue of two—is noted.

34. A note on *Tetrasporidium javanicum* Möbius.

M. O. PARTHASARATHY IYENGAR, Madras.

This alga which has been known only from Java, has been collected by the author at Madras. Möbius who first described it in 1893 created a new genus, *Tetrasporidium*, in the Palmellaceae for it. But later algologists have not sufficiently recognised this new genus. Chodat includes it under the genus, *Tetraspora*. West refers to the genus with a query. Wille and Printz give a doubtful place for it in the Palmellaceae by including it under "little known or uncertain genera." From a careful study of the alga in a living condition the author is, however, convinced that the genus established by Möbius is quite a valid one and that the alga is not a *Tetraspora* at all. A full account of the alga is given in the paper. The cells are chlamydomonadine in general structure, but do not possess pseudocilia or eyespot. There are, however, two actively working contractile vacuoles at the anterior end. The presence of the contractile vacuoles in this genus is interesting from a phylogenetic standpoint as only a few genera among the Palmellaceae still retain this chlamydomonadine feature.

35. A study of the soil flagellates and ciliates from different parts of India.

H. CHAUDHURI, Lahore.

The soils from 24 widely different parts of India have been surveyed for the ciliates and the flagellates. These included soils from both cultivated and uncultivated areas. The flagellates and the ciliates have been identified. Eight new species of the former and 22 of the latter have been recorded for the first time from India. The new flagellates are:—*Cercomonas crassicauda*, *Cercobodo agilis*, *Bodo caudatus*, *Bodo edax*, *Bodo saltans*, *Tetramitus spiralis*, *Tetramitus pyriformis* and *Monas* sp. The new ciliates include:—*Uritricha* sp., *Enchelys* sp., *Prorodon* sp., *Chilodon* sp., *Balantiophorus* sp., *Halteria* sp., *Lionotus* sp., *Strichotricha* sp., *Uroleptus mobilis*, *Uroleptus* sp., *Gonostomum* sp., *Oxytricha pellionella*, *Oxytricha* sp., *Pleurotricha lanceolata*, *Pleurotricha grandis*, *Stylonchia grandis*, *Vorticella* sp., *Spirostomum* sp., *Phascodolon* sp., *Colpidium* sp., *Pleuonema* sp. and *Cyclidium glaucoma*.

A new technique for their staining and identification has been described.

36. A discussion of the technique for the study of soil bacteria and soil protozoa.

H. CHAUDHURI, Lahore.

Different methods for the study of soil bacteria and soil protozoa including Winogradsky's direct examination method and also Cutler's method for culture of protozoa have been described and criticised, and new methods suggested. A new medium for the enumeration of the species in soil has been suggested as likely to prove generally superior to that which has usually been employed.

37. Further observations on the seeds and seedlings of
Eugenia jambolana Lam.

N. K. TIWARY, Benares.

This paper gives an account of cases of abnormality (a) in the structure of the seeds, and (b) in the behaviour of the plumule and the radicle during germination of this plant.

(a) *The structure of the seeds*: In previous communications (*Proc. Ind. Sc. Congress*, VIII, 1921, and XII, 1925) the writer recorded several cases of the abnormal structure of seeds and seedlings in six species of this genus. There it was shown that the seeds are often polyembryonic and possess from 3 to as many as 10 cotyledons, besides the normal number 2. In the present paper the author describes a seed with only one cotyledon without even a vestige of the other. This observation completes the series of cotyledonary numbers in the seeds of this highly variable plant.

(b) *The behaviour of the plumule and the radicle during germination*: The author observed during the course of his examination of the seedlings of this plant one specimen in which the plumule and the radicle instead of growing out through the gap between the two cotyledons, have each bored their way through the cotyledons themselves. Since only one specimen was found in an advanced stage of germination, it is not possible to interpret correctly the significance of this behaviour, but the conclusion does not appear unjustified that the normal orientation of the plumule and the radicle was so disturbed during the development of the embryo that they ultimately came to lie in a plane at right angles to their normal disposition, and may perhaps have also become more or less embedded in an outgrowth of the cotyledonary tissue, through which they could only ultimately emerge outside, by boring. Formation of callus was noticed. Such an occurrence has not been recorded in any other seed up to now.

38. Observations on the occurrence of axillary buds in the cotyledons.

N. K. TIWARY, Benares.

This paper is intended merely to record the presence and behaviour of axillary buds in connection with the cotyledons of the seedlings of the following plants:—*Cicer arietinum*; *Cassia tora*; *Impatiens balsamina*; *Pisum sativum*.

It was found that when the further growth of the seedling is checked by the plumule being injured this is continued by the development of the shoots from the axillary buds. In other, somewhat rare, cases the buds began to develop even while the normal course of development of the plumule was in no way interfered with. But in this case their growth took place at a fairly late stage. The behaviour of the buds in other seedlings is under observation.

39. Notes on the life-history of *Cyathodium* sp.

N. K. TIWARY, Benares.

The plants on which the observations here recorded were made were collected in a kacha drain on the Hindu University grounds during July–September, 1928. The specimens have been provisionally identified as being very nearly related to, if not identical with, *Cyathodium tuberosum* Kashyap (*Cyathodium penicillatum*).

In this paper is described, for the first time the author believes for the genus, the germination of the spores. While the course of their development agrees generally with the hitherto recorded cases, certain

peculiarities in the behaviour of the germ tube are described. The remaining life-history is briefly treated with reference to the previous accounts, specially those of Lang and Kashyap, the differences and novel facts being particularly noticed. This paper, it is believed, fills up a big gap hitherto remaining in the life-history of this genus of liverworts, owing to the absence of any published account of the germination of spores.

40. Some observations on the flowers of *Tecoma* sp.

N. K. TIWARY, Benares.

In this paper are described the behaviour of the Sun birds in stealing honey from the buds, and the pollination mechanism of the flowers. The morphology of the flower is briefly described.

41. A short account of an abnormal inflorescence of *Musa sapientum* Linn.

K. G. BANERJEE and G. P. MAJUMDAR, Calcutta.

The inflorescence is peculiar in two ways: firstly, by the branching of the main axis, a phenomenon of comparatively frequent occurrence; secondly, by the development of 105 perfect and semi-perfect *inflorescences in places of flowers* in the axils of spathes on the main axis. This is a somewhat rare phenomenon and shows that a flower in its undeveloped condition is a potential bud capable of developing into an inflorescence.

42. A note on some abnormalities in *Carica Papaya* Linn.

GIRIJA PRASANNA MAJUMDAR, Calcutta.

1. *Enation*—It is a very common phenomenon in Bengal. Five cases showing its development in different degrees are described from actual specimens. Their appearance in the present case can neither be explained with reference to the theory of *fission*, nor to that of *fusion*. Anatomical study of the smaller outgrowths shows the superficial nature of their origin. The influences, external or internal, which appear to stimulate this abnormal growth are still obscure and an anatomico-physiological study has been undertaken by the author for their elucidation, if possible.

2. *Abnormal fruits*—All the fruits produced by a particular plant show this abnormality, some of them containing as many as seven fruits, one inside the other. The present case clearly illustrates the phenomenon of proliferation, and the author concludes with Goebel that the flower axis is not always of limited growth, and that the gynoecium does not always terminate it.

43. A preliminary note on the pigments of the flowers of *Lantana Camara* Linn.

T. R. SATHE and V. SUBRAHMANYAN, Bangalore.

Microscopic study of the flowers shows a yellow pigment which occurs in chromoplastic globules and a second crimson one which is dispersed throughout the cell in which it occurs. Attempts are being made to obtain both in crystalline forms and to study their properties. The solubilities and reaction with SO₂ suggest that the crimson pigment is an anthocyanin. The yellow one seems to be a flavone.

44. The association of specific Bacteria with seeds and the influence of these on germination.

T. R. SATHE and ROLAND V. NORRIS, Bangalore.

It has been stated by previous workers that certain seeds e.g., *Cassia tora*, poppy, barley, etc., are accompanied by specific bacteria. It has also been suggested that in some cases the initiation of germination is dependent on the activity of such bacteria.

An examination has been made of various seeds, the latter being either removed from the fruit under aseptic conditions or else sterilised by means of mercuric chloride. Germination tests with sterilised seed under aseptic conditions were also made. In general little evidence has been obtained of the presence of specific organisms nor do the results indicate that such organisms play any important role in germination.

45. Study of the algal flora of Indian soils.

SYED ABDUL RAFAY, Bangalore.

A number of Indian soils have been examined and the different species of green algae, blue-green algae and diatoms present in them studied. It has been noted that there is a seasonal variation in the vegetation of these forms which show other physiological differences as well.

46. Analyses of tissues of *Dodonaea viscosa* Jacq. and *Zizyphus oenoplia* Mill in healthy and diseased conditions.

B. N. SASTRY, Bangalore.

Analyses of the leaf tissues of these two species of plants, which are also liable to "spike" disease, has been made in order to confirm the results obtained with Sandal. The results in the main show, a Nitrogen and Phosphorus excess, a Calcium deficiency, and an increase in diastatic activity and starch accumulation—results similar to those obtained with Sandal.

47. Enzymes of the Sandal leaf.

B. N. SASTRY, Bangalore.

A study of the enzymes in the normal and spiked leaves has been undertaken in order to find an explanation for the metabolic disturbances incident to the onset of the disease. A quantitative estimation of the enzyme activities shows a profound increase in the oxidase group of enzymes in the diseased tissue in addition to an increase in the diastatic activity already reported. It has been shown that the diastase of the spiked sandal leaf is less stable than the diastase of the healthy tissue in as much as the activity of the former is halved in about 16 days at 30°C. a period during which the enzymes of the healthy leaf undergo practically no deterioration.

48. Physiological studies in normal and spiked *Dodonaea viscosa* Jacq.

B. N. SASTRY, Bangalore.

A detailed study of the leaf, stem and root of *Dodonaea viscosa* in the normal and diseased condition with reference to mineral, nitrogen and carbohydrate metabolism has been made from samples obtained from three different localities. A study of the enzymes, specially the oxidases, has also been made.

49. A physico-chemical study of the tissue-fluids of *Phaseolus Vulgaris* at various stages of growth.

C. NARASIMHACHARI and B. N. SASTRY, Bangalore.

A detailed study of the physical constants and the chemical constituents of the tissue-fluids obtained from the leaf, stem and root of the plant at various stages of normal growth has been made in an endeavour (1) to examine the mutual relationship of the expressed sap of the various parts of the plant during successive stages of normal growth and to connect such growth changes with changes in the physico-chemical properties, (2) to study the distribution of the important plant substances, (3) to note the differences in such distribution during the various stages of growth; (4) to correlate the changes of distribution with changes in the physiological conditions of the plant and (5) generally to understand the nutritive mechanism of the living plant.

50. Studies in the physiology of yeasts.

V. SUBRAHMANYAN, Bangalore.

The production of involution forms by the different *saccharomyces* in presence of certain mineral salts has been noted and the influence of competition with other organisms studied.

51. Studies in the nutrition of the lac insect. Part V.

B. H. KRISHNA and M. SREENIVASAYA, Bangalore.

A study of the seasonal variation in some of the inorganic and organic chemical constituents of the tissue fluids of the stems of certain host plants (both attacked and free) of the lac insect has been made. It is shown that such studies throw some light on some of the requirements of the insect and the probable deficiencies in the host plants which would cause the insects to be parasitised.

52. Observations on the transmission of spike disease of sandal.

M. SREENIVASAYA, Bangalore.

Spike disease can be artificially transmitted to healthy stocks (1) by grafting diseased buds; and (2) by a transplantation of the meristematic tissues derived from diseased scions. Organic fusion of the tissues appears to be necessary for the transmission of the disease. The first visible symptom of the disease on the operated stalk manifests itself at the growing points both at the tip and at the root. The infective principle appears to affect the vegetative organs and the root system in quite different ways. Possibilities of natural transmission are discussed.

53. Nitrogenous constituents of the leaves of healthy and diseased sandal.

M. SREENIVASAYA and N. NARAYANA, Bangalore.

A comparative study of the nitrogenous constituents in the tissue fluids of the diseased and healthy leaves, has revealed significant differences in composition. The coagulable protein fractions, after isolation and purification, have been subjected to Van Slyke analysis. The water soluble fractions on analysis have shown a higher amino-nitrogen content and traces of nitrates in the case of spike. Work on the air-dried samples of leaf also confirm the above observations.

54. Proteoclastic activity of healthy and diseased leaves.

M. SREENIVASAYA and N. N. MURTHI, Bangalore.

In a previous communication (cf. Ind. Science Congress 1923, Chemistry Section, Abstracts, No. 108) it was shown that the diastatic activity was very high in the diseased leaves. The increased percentage of amino-nitrogen in the tissue fluids of the spiked leaves suggested the possibility of the amino groups playing the role of amyl-activators. The origin of the increased amino-nitrogen is traceable to the increased proteoclastic activity of the diseased leaves.

55. Comparative composition of the healthy and diseased leaves of sandal.

M. SREENIVASAYA and B. N. SASTRY, Bangalore.

The tissue fluids of the diseased and healthy sandal leaves have been analysed. A lower ash content, higher nitrogen and phosphorus content and a lower percentage of calcium characterise the tissue fluids derived from the spiked leaves.

56. Comparative composition of the healthy and diseased stems of sandal.

M. SREENIVASAYA, B. N. SASTRY and D. A. RAMA RAO, Bangalore.

The tissue fluid of the sandal stem, healthy and diseased, have been analysed. Higher ash and nitrogen content and a lower percentage of calcium characterised the diseased stem tissue fluid. The phosphorus and potash values are not significant.

57. A possible diagnostic index of spike disease.

M. SREENIVASAYA and B. VENKATESA SASTRY, Bangalore.

A statistical study of the analytical data of the various tissue fluids has been made. The ratio $\frac{N+P}{Ca}$ has been found to be very significant. The range of variation of this ratio for the healthy sandal is from 0.5 to 2. and for diseased sandal 6 to 8. These ratios vary with different areas. The ratio may also be of value in determining the stage of the disease.

58. Studies on the leaf tissue fluids of healthy and spiked sandal.

A. V. VARADARAJA IYENGAR, Bangalore.

Observations, extending over six months, have been made on the physical constants of the sap obtained from the leaves of healthy and spiked sandals; the constants investigated including pH, refractive index and conductivity. The influence of seasonal factors and of the disease on those constants is discussed.

59. On bunds and bunding on the grass and grazing areas of the Bombay Deccan.

L. B. KULKARNI, Poona.

1. Bunds and bunding on pastures are novelties in Western India.
2. Shallow bunds made of local stones in the hot weather, across all areas where there was any indication of wash or flow on the slopes of the

hills, were effective in preventing the flow of water and soil during the rainy season.

3. The bunds held up large quantities of water, silt and seeds of grasses and non-grasses.

4. These seeds were all of annual character, germinated earlier, and produced huge growth with denser and taller crop.

5. Such vegetation at the bunds was first attacked and closely grazed by the animals in the season when they were admitted in the area.

6. Bunds of a slightly larger dimensions put across the water courses feeding the nalla down below, in the beginning of the season, did to a great extent, stop further erosion.

60. On the pollen grains of certain Boraginaceae.

T. C. N. SINGH, Indore.

The pollen grain morphology of the following seven species have been studied:—(1) *Nonnea pulla* Lamk.: The mature pollen grains are elliptical with four equidistant germinal apertures on the exine along the equatorial plane with regard to the short axis. The intine bulges out of these but slightly. (2) *Anchusa* sp.: The pollen grains are exactly similar in shape and structure to those of *Nonnea pulla* except for the bulges of the intine, which are very much pronounced and the pollen grains comparatively less elongated. (3) *Gastrocotyle hispida* Bunge: Here the pollen grains are nearly spherical with nine germinal apertures on the exine along the equatorial plane. (4) *Borago* sp.: There are several weak spots on the exine, but in (5) *Heliotropium supinum* Linn. they are fewer and in (6) *Heliotropium marifolium* Retz. there are hardly any. (7) *Myosotis* sp.: The pollen grains are very minute being one-seventh the size of those of *Heliotropium marifolium*. They are elliptical with two notches one on either side. In top-view a pollen grain looks like a group of three arranged in a tetrad.

On the basis of the present study Miss Pope's proposed classification is criticised and the affinities of the genera studied, discussed.

61. On a new species of Scytonema.

YAJNAVALKYA BHARADWAJ, Benares.

The writer has found a new species of *Scytonema* growing as an epiphyte on the bark of *Mangifera indica*. It differs from the other epiphytic species in many respects, especially in (i) the presence of comparatively thin filaments which vary in thickness from young stage onwards, (ii) the presence of a thick sheath which is hyaline or slightly yellow in the young filaments but turns dark-brown and very hard in the old and mature ones, (iii) the total absence of heterocysts in the young filaments, (iv) the presence of only geminate pseudobranching, (v) the very common occurrence of biconcave discs of intercellular substance in connexion with the formation of hormogones and (vi) the formation of a new colourless sheath by the young hormogone inside the old dark-brown sheath which is cast off. Some cytological details have also been observed confirming some of the observations of Lemaire, Fritsch and Crow.

62. On some curious swellings in the filaments of some Burmese blue-green Algae.

S. L. GHOSE, Lahore.

In a number of blue-green Algae from Burma, regular swellings, either only in the sheath, or also in the trichome, were observed by the writer. In *Tolypothrix inflata* Ghose there are well marked swellings of

the sheath at fairly regular intervals, giving the filament a jointed appearance. In connection with these swellings sometimes pseudo-branches are given off. In *Aulosira fertilissima* Ghose also these swellings were observed. In *Scytonema ocellatum* Lyngb., var. *capitatum* Ghose the apex of the trichome is distinctly swollen; the cells are also larger. In another species of *Scytonema*, which is aquatic, the trichome is very thin, except at the apex where it is clearly swollen, thus looking like a trichome of *Rivularia*, only in the latter the base is swollen and not the apex. The function of these well-marked swellings is not quite clear.

63. Differential respiratory activities of green and yellow leaves.

P. PARIJA, Cuttack.

The respiratory activities of green and naturally occurring yellow leaves of Ivy (*Hedera* sp.) and *Euonymus* are compared in the laboratory. It is found that in the beginning yellow leaves respire at a lower rate (fresh weight being the basis for calculation), but after 2-3 days the rate for green leaves becomes lower than that of the yellow ones.

The senescent phase, i.e., the penultimate rise in respiration before death, appears earlier in yellow leaves than in green leaves.

While the effect of N_2 on green Ivy leaves is comparable with that on Cherry Laurel leaves (*Prunus laurocerasus*, gard. var. *rotundifolia*), namely, (1) a temporary rise in respiration in N_2 followed by a fall, and (2) on readmitting air after N_2 into the respiratory chamber, there is an excess output of CO_2 over the normal air rate, the effect of N_2 on yellow leaves is characterised by (1) a depression in CO_2 rate and (2) the absence of any after-effect.

The difference as regards the appearance of the senescent phase is explained by supposing that the organisation resistance in the yellow leaves is less than that in the green leaves, while the difference in the N_2 -effect is explained by supposing that the green leaves possess a reserve (probably glucosidal) which is absent in the yellow ones.

64. Dimorphism in a heterothallic Mucor.

S. L. AJREKAR and K. DHARMARAJULU.

A heterothallic Mucor, probably a new species, is described and attention is invited to a constant difference in thickness of hyphae between the conjugating + and - strains. This dimorphism may be either a step towards complete morphological differentiation between the sexes or it may indicate a tendency towards aborting one of the strains leading ultimately to the elimination of sexuality; more probably the latter.

65. A study of the intercellular system of the apple and of the correlation between the size of the intercellular spaces and the transpiratory and respiratory activities of the fruit.

H. P. CHOWDHRY, Lucknow.

This investigation was carried out to find whether there was any relation between the amount of intercellular space and the amount of transpiration and respiration.

The approximately proportionate amount of intercellular space was calculated from the weight, density of apple, and the densities of expressed juice.

It was found by plotting the specific gravity of 100 grams of apple against the rate of transpiration and the rate of CO_2 (Carbon dioxide) production that there is no correlation between the amount of intercellular space and the rates of these processes. It appeared that the variation in the intercellular space had no appreciable influence on transpiration or respiratory activity. This is probably due to the prominent part played by the skin in controlling the diffusion of gases and vapours from the apples.

66. The effect of the concentration of sap on the rate of respiration.

H. P. CHOWDHRY, Lucknow.

Fruits which are subjected to conditions which have a drying effect get their cell sap concentrated. It became necessary to find out whether the concentration of the sap thus brought about tends to have some effect on the respiration of fruits. Processes that bring about the concentration of the sap rapidly, such as by drying in hot air or by subjecting the fruits to current of dry air might have deleterious effect. It was therefore thought fit to bring about the gradual concentration of the sap by playing over current of air possessing different vapour pressures over the sections of Tangerines. This was brought about by bubbling CO_2 free air through various concentrations of Calcium Chloride solutions. The air was ultimately bubbled through NaOH (Sodium hydroxide) solution and the amount of respiration found.

Drying experiments carried on Tangerine orange sections by exposing to air of different vapour tensions indicate that a fairly long time is taken to reach the equilibrium point.

In a particular experiment which was carried on at a laboratory temperature of 9° to 10° C. the loss of weight of Tangerine section in air passed through 10, 30, 40 and 60% CaCl_2 (Calcium Chloride) solutions for a period of 12 days, was 4, 14, 15 and 22% respectively showing that apart from individual fluctuations the amount of dehydration has a linear connection with the amount of vapour tension of the air in which the material is exposed.

Respiration experiments show that a fall in the rate of respiration takes place when the orange material is exposed to air of low vapour pressure, the decrease generally manifesting itself after the second day when the material is well on the way to equilibrium point.

The material which is exposed to air passed through 10 or 20% CaCl_2 shows an initial rise in respiration as compared with the material which is exposed to higher concentrations of CaCl_2 solutions such as 30 or 40%. This fall synchronises with the greater loss in weight.

It seems that the explanation given by Maige and Nicelas for the rise in respiration with the increase in turgidity *viz.*, that it may be due to the increase in volume of protoplasm is a more satisfactory one in many cases.

After considering all the possible factors influencing the rate of respiration with the rise in the concentration of sap, it is pointed out that the fall in the respiration with the rise in the concentration of sap is not due mainly to this factor, but to the decrease in the surface of the protoplasm brought about by the dehydration on account of exposure to air having a lower vapour pressure than that of sap.

67. Studies in the embryology of *Carica Papaya* L. Part I.

S. P. AGHARKAR and I. BANERJI, Calcutta.

The development of embryo sac was investigated in one of the cultivated varieties of *Carica Papaya* L. and the following results were obtained.

The archesporial cell has its initiation in the hypodermal layer of the nucellus. A normal linear tetrad is formed of which the first three cells degenerate and the last one functions as the megaspore mother cell. In this the authors' results are different from those of Kratzer (1918) and Heilborn (1921), whose accounts also differ from one another in many respects. The megaspore mother cell divides in the usual manner and an octo-nucleate embryo-sac is produced of which the antipodals disorganise very soon, no trace of them being found in the fully differentiated embryo-sac. The polar nuclei lie close to the egg-apparatus but do not fuse till fertilisation.

68. Studies of the Charophyta of Bengal.

S. P. AGHARKAR and B. C. KUNDU, Calcutta.

In this paper a systematic account of the Charophyta collected from Calcutta and its suburbs is given in detail. The following species have been collected, and of these, those marked with (*) have been recorded or the first time from Bengal and those marked with (†) from India :—

- | | |
|---|--|
| *1. <i>Nitella acuminata</i> A. Br. | 7. <i>Chara Braunii</i> Gmel. |
| 2. <i>Nitella hyalina</i> Agardh. | *8. <i>Chara gymnopitys</i> A. Br. |
| †3. <i>Nitella capitellata</i> A. Br. (?) | 9. <i>Chara hydrophytis</i> Reich. |
| 4. <i>Nitella oligospora</i> A. Br. | †10. <i>Chara Bentharii</i> A. Br. (?) |
| 5. <i>Nitella furcata</i> Agardh. | *11. <i>Chara brachypus</i> A. Br. |
| 6. <i>Chara coralina</i> Willd. | *12. <i>Chara fragilis</i> Desr. |
| | 13. <i>Chara zeylanica</i> Willd. |

69. Occurrence of abnormal oogonia in *Chara Braunii* Gmel.

S. P. AGHARKAR and B. C. KUNDU, Calcutta.

The abnormality in question consists in some of the oogonia being borne on stalk cells which are very much elongated. It has been found in specimens of *Chara Braunii* Gmel. sent by Prof. Kashyap from Lahore. Mostly two to three oogonia have been found growing on the same branchlet-node with an antheridium under each of them. Similar abnormalities have been noticed before in *Nitella synacarpa* Thuil. by Ernst and in *Nitella mirabilis* J. Groves by James Groves but have not been recorded upto now in any species of *Chara* so far as the authors are aware.

70. Meiosis in *Cassia didymobotrya* Fresen.

M. L. SETHI, Multan.

Meiosis in the micro-spore mother cells of *Cassia didymobotrya* has been followed. The diploid and the haploid numbers of chromosomes are 28 and 14 respectively.

71. The fruiting branches of the cotton plant.

S. H. PRAYAG, R. C. PENDSHE and N. R. YARDI, Dhulia.

Recent investigations and the isolation of high yielding strains in the roseum variety of *Gossypium neglectum* cottons have led to the detection of certain peculiarities of the nature and behaviour of the fruiting branches of the cotton plant. Some of these are described in the paper and the observations so far made have given preliminary indications of high yield in the two strains known as N. R. 1 and N. R. 29. Attempts have also been made to ascertain the root behaviour of such strains and to study its relationship with high yield. Although some of the peculiarities noticed are very interesting the evidence is not sufficient to warrant any general conclusion. More data are being collected.

72. Enzymes from the seed of *Caesalpinia Bonducella* Fleming.

V. N. PATWARDHAN, Bangalore.

The seed has been examined regarding its enzyme content. In the resting seed Amylase, Protease, Urease, Peroxidase and Catalase have been found to be present. Invertase and Lipase appear to be absent. The absence of Lipase in the resting and germinated seeds is noteworthy in view of the fact that the decorticated seed contains from 15 to 20 per cent. of oil. The activity of the enzymes is increased during the process of germination.

73. Origin and development of internal bundles in the stem of *Rumex crispus*.

PANCHANAN MAHESHWARI, Allahabad.

The stem of *Rumex crispus* shows anomalous structure in having a number of internal bundles in addition to the normal vascular ring. Each normal bundle may have 1-5 internal bundles in its own sheath. It has been found that they are not formed by division of pith cells as mentioned by earlier investigators, but arise from the inner cells of the same procambial strand that produces the normal bundles. They are first formed as groups of phloem cells and then a cambium is differentiated on the outer side of the phloem, producing secondary xylem externally and secondary phloem internally. Later the cambium gradually extends completely round the phloem. Secondary growth becomes continuous on all sides, and consequently the best developed internal bundles are completely amphivasal. The xylem in the bundles is entirely secondary in origin, while the phloem is both primary and secondary. There is a progressive development of the internal bundles in size, number, and structure from the apex to the upper end of the lowest internode. From here they gradually decrease till in the basal region they are entirely absent.

Young plants up to about two years in age are quite normal and give no indication of internal bundles. They are also absent in the leaf-traces or in the petiolar bundles.

It is concluded that the internal bundles are not vestigial organs, but a recent development of unknown significance, but they may be related to greatly increased needs of translocation.

74. Secondary growth in the stem of *Boerhaavia diffusa* L.

PANCHANAN MAHESHWARI, Allahabad.

It has long been known from the researches of PETERSON, De BARY, SOLEREDER, and others that several genera of the Nyctaginiaceae and allied families present an anomalous structure in having an extrafascicular cambium formed outside the ring of normal bundles. It is also said that the activity of this ceases after some time and successive cambiums are formed from the outer cells of the pericycle in centrifugal succession.

The present investigation on *Boerhaavia diffusa* shows that the stem has two big medullary bundles in the centre, surrounded by an outer ring of somewhat loosely arranged bundles, which in turn is again surrounded by another ring of bundles, which are also primary but very much smaller. Serial sections from the growing point downward show that the old conception of a new 'extrafascicular cambium' arising from the pericycle is incorrect. This cambium is merely produced by the joining up of the fascicular cambiums of the small outermost bundles in a normal way. After this cambium has produced some secondary phloem on the outer side, its activity slows down and the outer cells of its own products

become meristematic giving the appearance of a new cambium. This process goes on till in the basal portions of the oldest stems there may be four or five rings of secondary growth.

It has also been found that in the bases of the prostrate stems cambial activity is greater on the lower side than on the upper.

75. Development of the embryo sac and haustorium in *Ilysanthes parviflora* Benth.

M. A. SAMPAT KUMARAN and C. V. K. IYENGAR, Mysore.

Ovule of *Ilysanthes parviflora* has a single thick integument. The nucellus consists of a large archesporial hypodermal cell with a layer of jacket cells all round.

There is a linear tetrad of megaspores of which the innermost one, which is the largest, gives rise to the embryo sac.

There is the conspicuous "Epithelium" which belongs to the integument and which keeps pace with the development of the embryo sac.

In the perfect embryo sac the antipodal end is cut off, and three small antipodal cells are seen at this region; the lower region of the embryo sac is surrounded by the Epithelium.

After fertilization the antipodals and the synergids degenerate.

The endosperm nucleus divides after fusion, the first division followed by wall formation.

The cell cut off towards the chalazal end gives rise to two prominent haustoria by a longitudinal division of this cell.

The cell towards the micropylar end by a series of longitudinal and transverse divisions gives rise to the micropylar haustoria (four in number) towards the micropyle and the endosperm towards the interior.

The chalazal haustoria are absorbed during the older stages of the embryo, only the micropylar haustoria which are simple and unbranched remaining functional even after this.

The chalazal haustoria show a tendency towards coenocytic nature during degeneration prior to disappearance.

76. Chromosome numbers in cucurbitaceæ and other plants.

J. J. ASANA and R. N. SUTARIA, Ahmedabad.

With a view to finding chromosomal variations, if they exist, in the representative species and genera of cucurbitaceæ and other natural orders, we have been studying several Indian plants for some time past. A brief statement of some of the observations we have so far made is here recorded.

Luffa aegyptiaca Mill.:—The chromosomes in the male flowers in this species are very small and the haploid number is most probably 13. It is interesting to note in this connection that Hemlich. L.F. in Proc. Nat. Academie Sci. U.S.A. 13 (3), 1927, records that the haploid number of chromosome in *cucumis sativus* is 7, while E. F. Castetter in the American Journal of Botany 13 (1), 1926, records 20 as the haploid number of chromosomes in *cucurbita maxima*.

Moringa pterygosperma Gaertn.:—Chromosomes are small and somewhat rounded. The haploid number is probably 14.

77. Milk potometer.

S. C. BANERJI, Calcutta.

A simple device to demonstrate to a large audience the presence of transpiration current in a detached twig by using dilute milk as index

in a fine capillary tube and a microprojecting apparatus. Effects of change of temperature and humidity on transpiration can also be readily ascertained by the arrangement.

78. Leaf glands of *triumfetta* sp ?

L. N. RAO, Bangalore.

On the middle and the principle veins on the underside of leaves of *Triumfetta* sp ? are found small swellings the summit of which is occupied by nectariferous glands. Generally three such glands are found per leaf being situated nearer the base than the tip of the leaf.

There seems to be some relation between the development of the gland and the vein on which it is situated : the gland on the middle vein i.e., the mid-rib of the leaf being radially symmetrical and the ones that are on other veins being typically asymmetrical.

The glands communicate with the exterior by means of long and narrow ducts which are lined by cubical epithelial cells.

The secreting epithelium consists of a layer of structures of the nature of multicellular trichomes which have a broad base and a narrow tip.

The development of these trichomes has been studied. They always take their origin as a papillae on the mid-rib of a very young leaf. Then it develops into a trichome of 4 to 5 cells. By this time the gland formation by the growth of the surrounding tissue will be over. Lastly the cells undergo divisions parallel to the long axis of the trichome.

There does not seem to be any relation between these glands and the vascular system (of the leaf) which they overlie. The glands are supplied chiefly by the basement layer of parenchymatous cells.

The secretion of these glands is of the nature of Glucose as shown by the brown precipitate with Fehlings reagent. The exact roll of the secretion in the economy of the plant is not very clear.

79. Stratification of nitrates in natural soils of Lucknow in the form of liesgang rings and the significance of this phenomenon in agricultural practice.

S. K. MUKERJI, Lucknow.

An intensive study of the soil conditions of Lucknow is in progress. Some of the principal edaphic and climatic factors which exercise profound influence on the growth of plants e.g., water content, organic content, nitrate content, carbonate content, hydrogen-ion-concentration, temperatures of the soil and air at different levels, etc., are being investigated.

In the course of this work, it has been found that the nitrate content of certain soils that have been examined so far, behaves in a remarkable manner. Contrary to the general views held so far with regard to distribution of nitrates at successive depths of the soil, it has been discovered that the nitrates occur in the soils investigated at different horizons in the form of Liesgang rings. The causes which may contribute in bringing about this kind of stratification of nitrates in soils can be grouped into three main categories, viz. :—

- (1) Possible occurrence of nitrifying bacteria in different strata corresponding to those in which the nitrates occur.
- (2) Possible distribution of laterals bearing nodules on the root-system of leguminous plants which may enrich definite layers of the soil with nitrates, and lastly
- (3) Colloidal adsorption of nitrates by some soil colloids.

An investigation of the electrical charges borne by the nitrate—and non-nitrate—bearing strata of the soil has revealed the presence of positively charged bodies in nitrate—bearing strata and negatively charged ones in the non-nitrate—bearing layers.

A theory is advanced that the stratification of nitrates in the soil is brought about by colloidal silica taking up a positive charge by uniting with electrolytes such as salts of Potassium and Sodium and in its turn adsorbing the negatively charged nitrate ions.

If this phenomenon be shewn to occur widely in agricultural lands, then for nitrate-demanding crops like wheat deep tilling will have to be resorted to by the Indian agriculturists.

80. The hydrogen-ion-concentration of the soil as a factor of vital importance in governing the distribution and growth of plants.

S. K. MUKERJI, Lucknow.

Since Sorensen shewed in 1909 how important a factor the hydrogen-ion-concentration was in the domain of biology, including plant and animal physiology, numerous researches have been published from time to time bearing on the subject. The works of Wherry, Olsen, Clark, Arrhenius, Atkins and Salisbury among others have materially advanced our knowledge with regard to the important part played by hydrogen-ion-concentration in governing plant distribution and in modifying plant growth.

As a result of soil analyses of over three hundred soil samples supplemented by physiological experiments the author has observed that hydrogen-ion-concentration of the soil exercises a profound influence on the distribution and growth of plants. It has been found that there is a range of hydrogen-ion-concentration within which a certain species will grow. Too high specific acidity below the range of PH 4 and too high specific alkalinity above PH 8 in the medium in which a plant grows are found to act as limiting factors so much so that they tend to completely retard the growth of the species in question and may in the end be instrumental in the disappearance of the plant altogether. Certain plants under conditions of physiological experiments show a definite gradation in the increase of height, fresh weight and dry weight of their aerial shoots with progressively diminishing hydrogen-ion-concentration. From these experiments it appears that the maximum growth is attained nearer the neutral point. It is probable that absorption of ions of various salts which are required for the healthy growth of a plant may take place actively at the neutral point, thus resulting in more vigorous growth in this region of hydrogen-ion-concentration.

Then again, the hydrogen-ion-concentration has been found to exercise a marked effect on the distribution of species in nature. Plants which favour acid conditions will not grow where the soil is becoming progressively alkaline and *vice versa*.

Section of Geology.

*President :—*CYRIL S. FOX, D.Sc., M.I.Min.E., F.G.S.

Presidential Address.

GEOLOGICAL ASPECTS OF THE FORMATION OF COAL.

INTRODUCTION.

I am not insensible to the honour you have conferred on me by asking me to become President of the Geological Section of the Indian Science Congress this year. I was glad to accept the offer as it gives me an occasion for showing that officers of the Geological Survey are anxious to co-operate with other geologists in India. There are so many interesting and important geological problems awaiting investigation in this country, where workers are so few, that I am sure you feel we should miss no opportunity for meeting and discussing our observations and results. Such an interchange of information will help us to avoid all unnecessary overlapping of research work, and may, in the near future, enable some of us to combine in a systematic and comprehensive attack on the larger problems of Indian Geology.

There is perhaps, at the present time, no geological subject which has attracted wider public and scientific attention than that of coal, particularly the utilisation of coal to the best and most economical advantage of the peoples of all countries. This interest is evident from the literature published in Great Britain and elsewhere. In these countries the payment of subsidies to workers, and questions of nationalization of mines and minerals, have been backed by expenditure on costly investigations (for the production of smokeless fuel from raw coal), and followed by grants for a detailed study of the nature and history of coal. Interest in these investigations and researches is not lacking in India. We have our own peculiar fuel problems. The fuel question in India is far more important than has been realised outside certain limited circles. The coal reserves cannot be estimated in mere terms of actual mineral value at market rates. We do not know how much of the calculated reserves can be profitably mined.¹ It is certain that with the condition of the trade as it is to-day the methods of mining which are of necessity being employed will lead to the irretrievable loss of large quantities of good quality coal. India cannot afford this waste. Her reserves

¹ *Rec. Geol. Surv. India*, Vol. LXI, pt. 3, 1928, pp. 313-314.

of good coal are small when compared with those of England and France. In this country, of over 300 millions of population the domestic demand for household coal is almost negligible. There are, however, potentialities for a very attractive market in the future for coal in the form known as "poora koela" or soft coke.¹ One of the most pressing needs of the country is the substitution of cheap coal by the agricultural population for the valuable manure they now use as fuel.

During the last four years my official duties have been devoted, almost entirely, to the examination of the coal-fields of India, and to a study of the various coals met with in this country. The stratigraphical and petrological data which my field investigations and laboratory studies have gathered in are interesting. Some of the facts and conclusions may be of interest to you, and I have, therefore, taken the liberty of discussing them to-day. I propose to deal with the following points as briefly as possible:—

1. Occurrences of Indian coal.
2. Quality and origin of Indian coals.
3. The constitution of Indian coals.
4. Formation of Indian coal.
5. Concluding remarks.—A summary.

1. INDIAN COAL OCCURRENCES.

Coal, either in thick workable seams or as small lenticles, has been found in India in rocks ranging in geological age from the Lower Cambrian up to the Pleistocene. In all cases it appears to be certain that the coal was formed from plant remains, and almost always from material of a terrestrial flora. The evidence is quite clear that coal-forming processes have repeatedly been in operation since early geological times. This is in agreement with the conclusions of oil geologists that the processes of petroleum formation have also operated throughout the same geological time *i.e.*, since the Cambrian period.²

The richest workable coal-seams in India are of course those of the Lower Gondwana period in the coal-fields of the Damuda valley and other areas in the Peninsula. In their type area, the Damuda or coal-bearing series is nearly 7,000 feet thick. In the Jharia field, in the lowest stage (Barakar) of this series, there are no less than eighteen workable seams totalling nearly 200 feet of coal. In the upper stage (Raniganj) of the Raniganj field there are roughly six workable seams of a total

¹ 'Capital,' Vol. LXXXI, 1928, pp. 2-3 (July 5) and 58-59 (July 12) "Indian Soft-Coke."

² *Proc. Empire Min. Met. Congress*, Part III, 1925, pp. 25-26. "Petroleum Geology." T. Dewhurst.

thickness of roughly 50 feet of coal. In both stages the seams are interbedded between shales (usually below) and sandstones (frequently above). The sandstones are often coarse and conglomeratic, with, in many cases, the pebbles resting on the coal. There are numerous instances of current-bedding and overstepping of the sandstones and shales on to the coal seams. The seams are laminated and well-bedded even when more than forty feet thick. When traced in one or other direction the coal seams are found to split or come together. It is not unusual to find a coal seam passing laterally into carbonaceous shale.

These coal-bearing strata are clearly sediments which have been deposited in fresh-water, either in wide river valleys or in extensive shallow lakes. Except in the single case at Umaria in South Rewa,¹ no marine fossils are found associated with the Lower Gondwanas in the Peninsula. There is a remarkable paucity of animal remains of any kind in these coal-measures. On the other hand the strata contain a rich fossil flora of terrestrial plants—stems, leaves and seeds. The silicified trunks of trees and fossil-wood are present in some of the sandstones. Tree stems with the outer or cortical portion converted into bright coal are met with in the roofs of some seams.² Only in one case have the remains of large vertebrates been found in strata of the Damuda series,³ but there are several instances of reptilian and amphibian remains being found in the strata of the next series, Panchet, above those of the Damuda epoch. The evidence as a whole is suggestive of the coal-seams being true sediments—of detrital vegetable matter. It is difficult to say definitely if the vegetable material drifted from a distance or accumulated in the marshes and swamps around which the plants lived and died.

In Assam the Coal-measures are of Tertiary (Miocene to Oligocene) age. The seams are interbedded between shales and sandstones. Unlike the Gondwana strata, which are locally faulted and buckled, the Assam coal seams and associated rocks have been somewhat severely folded. Fossil remains are not common and, when found, are usually poorly preserved. When identifiable leaves and plant remains are obtained, they are recognised as the parts of terrestrial vegetation. On the other hand the fauna is usually of invertebrate marine forms. It is generally agreed that the Coal-measure series of Assam were deposited in the shallow waters of a sea—probably at the head

Tertiary (marine)
coal-seams.

¹ *Rec. Geol. Surv. India*, Vol. LX, Pt. 4, 1928, pp. 367-398, 399-410.

² As an example, No. XVII seam, Buliari (Jharia coal-field).

³ *Pal. Indica*, Ser. IV, Vol. I, 1885. Also *Mem. Geol. Surv. India.*, Vol. X, 1873, p. 159. The Labyrinthodont from near Bijori, Chhindwara Dist., C.P.

of a gulf. This is also true of the equivalent strata, the Pegus, of Burma, in certain horizons of which coal seams also occur.

Perhaps the most interesting feature of the Coal-measure series of Assam and the Pegus of Burma is the intimate association of petroleum with the coal. In Assam the intimate connection of the coal and petroleum occurrences is too obvious to escape attention.¹ Closer observation has shown that where coal is abundant in these coal measures petroleum is scarce and *vice versa*. Sir Edwin Pascoe says²:—"In Assam....in nearly every separate oil area, coal seams are found among the oil sands themselves, but it is especially in the horizons higher up that coal in any bulk is found.... Not only is there this vertical relationship, but there is another accompanying it of a geographical nature, according to which coal seams show a preference for the margins of the gulf in which the Tertiary sediments accumulated, while petroleum is usually found a little further from the coast."

In north-west India, in Baluchistan, the Punjab Salt Range and Jammu (Kashmir), workable coal occurs in the Laki stage (Middle to Lower Eocene) of the Tertiary rocks.³ The seams are intercalated between pyritiferous shales and sandstones with limestones in association. Identifiable plant remains are scarce, but the carbonized woody parts of plants are occasionally met with in the coal. The strata above and below, and sometimes the shaley coal itself, is full of invertebrate animal remains—chiefly foraminifera—all marine types. Judging by the plant remains in the lignite of Bikanir (Palana) in Rajputana, which is on exactly the same horizon (Laki stage) as the Salt Range and other coals in this region and which were evidently accumulated in the same marine region as these black and brown Eocene coals, it appears that the vegetable matter is the debris of terrestrial plants.

The Palana lignite is characterized by the large amount of fossil resin which occurs in it. The coals of Baluchistan and the Salt Range also contain small amounts of resin. This is also true of the Tertiary coals of Assam. The strata in the several areas of the north-west have suffered different degrees of tectonic disturbance. The lignite beds of Rajputana barely suffered any movement at all, the Tertiary rocks of Baluchistan are folded, while the coal-bearing beds in Jammu have been involved in the orogenic movements which culminated in the uplift of the Himalaya. It is significant in this connection that the vegetable matter in the Tertiary rocks of Rajputana have only been converted into lignite while the coals of Jammu (Kalakot) are distinctly anthracitic.

¹ *Mem. Geol. Surv. India*, Vol. XII, Pt. 2, 1876, p. 88.

² *Mem. Geol. Surv. India*, Vol. XL, Pt. 2, 1914, p. 322.

³ *Rec. Geol. Surv. India*, Vol. LXI, Pt. 2, 1928, pp. 160-163.

Here again in these marine Eocene (Tertiary) strata containing coal there is an association of petroleum. The Laki stage is in particular looked upon as the petroleum horizon, which thus corresponds with the coal horizon. The two substances again show the curious features that were noticed by Sir Edwin Pascoe in Assam and Burma. This authority on oil questions, speaking generally, while discussing the origin of petroleum says¹:—"We are led to conclude that, in places where such an association can be recognised, they (coal and petroleum) were probably derived from not dissimilar sources, under different but comparable conditions. Where conditions were eminently favourable for the formation of coal, they apparently were not so for petroleum, since beds bearing thick seams of coal are apt to contain little or no petroleum; on the other hand, where conditions did not permit of more than thin layers and local patches of lignite or coal being formed, larger quantities of oil are liable to be found one is tempted to say instead of coal."

Less important from an economical point of view, but of considerable interest otherwise, are the seams of coal and lenticles of coaly matter in rocks other than those already mentioned. Workable coal-seams occur in other marine strata in Assam. The beds in the Garo hills, from fossil evidence, are of Cretaceous age. There are Eocene coals at Cherrapunji. Plant remains and thin lenticles of coal occur in the marine Lower Cretaceous (Umia) beds in Kachh (Cutch). The Upper Gondwana (Lameta) coal in the Nerbada valley, near Jubbulpur, occurs in fresh water deposits of Lower Cretaceous age. It is probable that certain other, thin, Upper Gondwana coals in the same general region (Satpura highlands), may be older—probably of Jurassic (Oolitic) age. True Jurassic coals and carbonaceous beds with plant remains occur in the Southern Shan States (Burma) and the Punjab Salt Range. These occurrences fill in the gaps between the Tertiary coals and the Permian (Gondwana) coals of India. Definitely Lower Palaeozoic coal, in rare lenticles, has been found in the black shales of the Vindhyan system in the Son valley near Rhotasgarh. These Bijargarh shales have been correlated with the Suket shales of Rajputana, in which, near Neemuch, fossils (? *acrothele*) with Lower Cambrian faunistic affinities were found several years ago by Mr. H. C. Jones.² It is thought that the Vindhyan strata were deposited in the sea, and it has been suggested that the Neemuch fossils may possibly be plant remains. Carbonaceous shales, which have repeatedly been mistaken for coal, also occur in a lower horizon, in the Semri series³ below the

¹ *Mem. Geol. Surv. India*. Vol. XL, 1912, p. 237.

² *Rec. Geol. Surv. India*, Vol. LX, 1927, p. 18; also LXI, 1928, p. 21.

³ *Mem. Geol. Surv. India*, Vol. VII, 1869, p. 45; *Rec. Geol. Surv. India*, Vol. XXXIII, 1906, p. 269.

true Vindhyan strata, but no actual coal has been found in these unfossiliferous pre-Cambrian rocks.

2. QUALITY AND ORIGIN OF INDIAN COALS.

The introduction of the Indian Coal Grading Board is evidence of the necessity of classifying coals for trade purposes. The existence of scientific systems of classification in all coal producing countries is indicative of the occurrence of many varieties of coal. In India, in the Lower Eocene coals of the north-west, we have an irregular range from the brown lignite of Bikanir to the anthracitic coal of Jammu. Although these fuels are of the same geological age, they occur at considerable distances apart and, to-day, in isolated fields.

Proximate analyses of these Eocene coals and some of the Tertiary coals. Miocene coals of Assam are given below :—

Tertiary Coals.

	Moisture.	Volatile Matter.	Fixed Carbon.	Ash.
<i>Assam. (Miocene)</i>				
Borjan (Resinous)	.. 3.6	55.78	39.3	1.32 C.
Borjan (Brights)	.. 4.35	48.00	45.7	1.95 C.
Watching	.. 8.15	38.48	52.98	0.39
Namdang	.. 2.04	42.27	54.48	1.21 C.
<i>Rajputana. (Lr. Eocene)</i>				
Palana Resin	.. 0.65	99.09	0.06	0.2
Light Lignite	.. 5.13	71.45	11.57	11.85 C.
Dark Lignite	.. 12.55	46.67	11.38	4.40
Wet Lignite	.. 45.6	25.13	24.92	4.35
Dry Lignite	.. 8.5	41.8	40.8	9.5
<i>Baluchistan. (Lr. Eocene)</i>				
Mach	.. 10.71	41.43	45.68	2.18 C.
Mach	.. 10.9	33.1	41.0	15.0
Digari	.. 7.7	43.3	44.7	4.3
Khost	.. 2.29	41.51	46.52	9.68 C.
Sharig	.. 6.8	40.8	47.6	4.8
<i>Salt Range, Punjab. (Lr. Eocene)</i>				
Dandot	.. 5.87	43.65	38.04	12.44 C.
Dandot	.. 6.13	36.81	47.17	9.89
Barochi	.. 10.87	38.71	42.81	5.04
Makerwal	.. 2.40	43.54	41.38	12.68 C.
<i>Jammu, Kashmir. (Lr. Eocene)</i>				
Kalakot—7-foot seam, lower measures	.. 0.63	12.45	78.12	9.0 C.
Kalakot—16-foot seam, upper measures	.. 4.62	14.54	69.44	11.4
Sair—upper seam, upper measures	8.43	20.93	60.16	10.48
Sair—, " " " "	8.04	25.00	60.54	6.42

C = Strongly coking coals.

N.B.—All the above analyses are of picked specimens and not samples. These analyses have been compiled from

various sources. Many were made in the Geol. Surv. Lab., Calcutta, by Mahadeo Ram.

There is a considerable range in the variety of the coals obtained from the numerous seams in the Gondwana (Permian) coals. Jharia coalfield. These differ in geological age, from Lower Permian, for the basal (numbers I to X) seams of the Barakar stage, to Upper Permian, for the seams in the Raniganj stage of the same field. When these seams are compared with each other and with the seams of the Raniganj stage in the Raniganj field remarkable differences in character are found, which, to some extent may be evident from the analyses given below :—

Gondwana Coals.¹

	Moisture.	Volatile Matter.	Fixed Carbon.	Ash.
<i>Jharia—Barakar Stage.</i>				
Matiagara (II) Seam	.. 0.65	14.2	68.0	17.8
Nardkharki (V)	.. 0.65	14.1	66.2	19.7
Dhansar (VIII)	.. 1.0	17.3	61.57	21.13
Dhariajoba (X)	.. 1.0	19.0	62.4	18.6
Kenwadih (XII)	.. 0.75	20.1	65.30	14.6
Khas Jharia (XII)	.. 1.15	21.65	62.35	16.0
Bhuggutdih (XIV)	.. 1.27	22.85	64.7	12.45
<i>Jharia—Barakar Stage.</i>				
Lodna (XIV) Seam	.. 1.6	24.6	61.0	14.4
Bhagaband (XVI)	.. 1.3	24.5	60.2	15.3
Bhagaband (XVII)	.. 1.6	27.2	59.6	13.2
Bhutgooria (XVII)	.. 2.0	28.13	58.85	13.02
Noonudih (XVIII)	.. 1.80	28.8	59.3	11.9
Jamadoba (XVIII)	.. 1.70	28.10	56.80	15.10
<i>Jharia—Raniganj Stage.</i>				
Murilidih	.. 2.2	29.30	57.00	13.2
Bhatdih	.. 1.7	31.0	54.5	14.5
Huntodih (top)	.. 2.07	32.2	52.75	15.05
N. Pipratnir	.. 1.97	32.0	53.3	14.7
<i>West Raniganj—Raniganj Stage.</i>				
Nursamuda	.. 6.1	33.3	52.10	14.6
Dadka	.. 5.3	32.60	53.7	13.7
Ragnathbati	.. 3.9	31.0	57.9	11.1
Dishergarh	.. 2.57	33.95	54.95	11.1
Hatnal	.. 2.15	31.05	48.9	20.05
Sanctoria	.. 2.81	32.0	59.00	9.0
<i>East Raniganj—Raniganj Stage.</i>				
Ghusick	.. 7.55	34.8	52.6	12.6
Nega	.. 6.4	32.1	53.65	14.25
Searsole	.. 7.5	31.1	52.3	16.6

¹ Results given above are on a moisture-free basis. All the Jharia coals coke. Seams XII to XVIII give a hard coke. The Raniganj seams are generally non-coking except Dishergarh and Sanctoria. Practically all these analyses were made in the Govt. Test House, Alipur, Calcutta.

	Moisture.	Volatile Matter.	Fixed Carbon.	Ash.
Bowla	.. 8.3	33.8	54.7	11.5
Joba	.. 5.5	31.5	55.7	12.8
Koithi	.. 4.7	33.2	53.7	13.1
Poniati	.. 4.85	32.83	55.8	11.35
Poniati	.. 6.00	30.7	59.9	9.4
Poniati	.. 8.8	30.0	59.1	10.9
Samla	.. 11.0	31.5	57.1	11.4
Taltore	.. 6.3	29.6	55.00	15.40

N.B.—All analyses of samples collected by officers of the coal grading Board. Analyses made at Alipur Test House.

In the analyses of the Jharia coals the seams are numbered from the base of Barakar stage, I to XVIII. Practically all the seams in the Barakar stage yield coke, but the hardest coke is obtained in the upper seams from XII to XVIII. The steady decrease in Fixed Carbon and the increase in Volatile Matter as the younger seams are reached is evident in the seams from both the Barakar and the Raniganj stages in the Jharia coalfield. The Moisture Content is relatively small throughout the coals of the Jharia field. Turning to the Raniganj stage coals of the Raniganj field—the high general Moisture Content attracts immediate notice. In the western end of this field there is a decrease in the Moisture Content of the coals as the lower seams are reached *i.e.*, from the Nursamuda to the Sanctoria. In the eastern part of the same field there is no apparent order—except it be that the moisture content is greater in the coal from outcrop workings, and less in the coal from deeper workings where no water has previously saturated or affected the coal. The order is Ghusick at the top and Samla and Taltore seams at the base of the Raniganj stage in the eastern part of the Raniganj field.

From the above analyses it will be seen that the Gondwana coals are all of the bituminous variety. Those from the base of the Barakar stage approach semi-anthracites in quality, but are nevertheless true bituminous coals. Seams I to IX (Barakar stage, Jharia), would be classed as *Meta-bituminous* in Seyler's classification¹ and *Bituminous A* in Parr's classification²: Seams X to XVIII (Barakar stage, Jharia) belong to *Ortho-bituminous* or true bituminous coals according to Seyler and to the *Bituminous B* of Parr. The Raniganj stage coals of Jharia and of West Raniganj fall into the same type—*Bituminous B*, but are easily capable of being placed in a separate class³. The Raniganj

¹ Practical Coal Mining, Vol. I, 1907, p. 91; also see C. A. Seyler 'The Classification of Coals' *Fuel*, Vol. 2, 1923, p. 272 and 'The Chemical Classification of Coal' in *Fuel*, Vol. 3, 1924, 79.

² The 'Classification of Coal' by S. W. Perr. University of Illinois Bull. Vol. XXV, No. 48, 1923, (July).

³ This has been done for trade purposes by the Indian coal grading Board.

stage coals of East Raniganj belong to Parr's *Bituminous C* type, and would be *Para-bituminous* coals according to Seyler's classification. The Tertiary coals of Assam, Baluchistan, and the Punjab straddle across almost all the varieties, but are largely grouped among Parr's *Lignites and Cannels*. There is little doubt that no rigid system of classification can be devised for the Indian coals. They grade insensibly from one to the other. The pressure to which they have been subjected and the amount of resin they contain clearly affect their quality in spite of the fact that they have been formed from vegetable material which was of similar composition originally.

The fact that the *volatile content* of a coal has been found important in questions of coal classification and similar purposes *e.g.*, Fuel-Ratios¹ and Carbon-Ratios,² suggests that though this *volatile matter* is readily driven off by sufficient heating it is in chemical combination with what becomes the *fixed carbon* after distillation. This opens the door to another possibility *i.e.*, that the true coal-substance, however complex in molecular structure, might be of uniform ultimate composition (in all types of coal) when first completely formed from the vegetable debris. The variety of coals would, therefore, be merely indicative of the stage of maturity attained by the coal-substance in the progress of its metamorphosis from plant matter, through peaty material and lignite, to the bituminous coals and anthracite.

The existence of (1) coals of the cannel and (2) high-moisture type are suggestive, respectively, of (a) high resin content in the original plant debris, and, of the absorption of water by the coal-substance at some period subsequent to coal formation. They are special cases—in the same sense that carbonaceous shales are special cases of coals with a high content of clayey matter. There is also the possibility that a combination of resinous or other plant matter *e.g.*, spores, with, perhaps clay, may furnish special types of hydro-carbon shale *e.g.*, tasmannite, and thus the subject of oil-shales become included in the same category, *i.e.* if petroleum is a product of vegetable origin.³ In the case of common bituminous coal the starting point is always vegetable matter of terrestrial plants, and since the same class of bituminous coal, whether obtained from India, England or the Arctic regions, is always very similar, the conclusion is that the composition of vegetable matter of terrestrial plants has on the whole remained remarkably uniform throughout geological time.⁴

¹ Volatile matter ÷ fixed carbon, on dry, ash-free basis.

² D. White, Jour. Wash. Acad. Sci., Vol. 5, 1915, pp. 189-212. I. W. Jones, Eco. Geol., Vol. XXIII, 1928, pp. 353-380.

³ F. W. Clarke, Data of Geo. Chemistry, 1920, p. 741.

⁴ 'Coal in Great Britain' by Walest Gibson, 1920.

The general uniformity in the composition of plant material of terrestrial origin is fully recognised to-day.¹ It is also known that this plant material, when air-dried, probably averages 30 to 50 per cent. of cellulose. In raw cotton the cellulose is as much as 90 per cent. The average percentage of lignin in plant material is probably 25, with none in raw cotton and as much as 40 per cent. in some beech trees. True coals are said to contain no cellulose. Cellulose has been found in mature peat. It is known that cellulose is still present in fully fermented silage,² when, presumably, bacterial action has ceased. The accumulating evidence, therefore, is, that, however active bacteria or fungi may have been before the dead vegetable matter was submerged, their activities were not subsequently long continued under water. The conditions of submersion, while fatal to almost all life, were evidently exceptionally favourable for the preservation of the material engulfed. Nevertheless carbonization or a slow process of ageing evidently sets in, and the plant material is steadily metamorphosed into coal—accompanied by the liberation of water, carbon dioxide, marsh gas and carbon monoxide. In the case of the lignite of Palana (Bikanir) the complete conversion to coal has for reasons given later been arrested. In the case of the Kalakot (Jammu) anthracitic coal dynamic squeeze appears to have expedited the degree of devolatilization or carbonization.

Nearly all the Gondwana coals show three visible components, which, judging by the literature of other countries, are the well-known coal constituents (1) *vitrain* (vitrit) or bright coal (glanz kohle), (2) *fusain* (fusit) or mineral charcoal (faserkhole) and (3) *durain* (durit) or dull coal (mattekhole). Analyses of these constituents show that the *vitrain* is the purest material, judged on the ash content. *Durain* is sometimes high in ash as in the analysis below,³ but the ash content is frequently as low as 6 per cent. as in the case the talchir coal.

	Moisture.	Ash.	Volatile Matter.	Fixed Carbon.	Sp. Gr.
(Keshalpur)	1.04	0.78	26.10	72.08	1.291
<i>Vitrain</i> (Purshottampur)	8.55	3.16	30.27	58.02	
<i>Fusain</i> (Rampur, Ib river)	3.06	7.89	23.34	65.71	
<i>Durain</i> (Purshottampur)	5.13	12.82	31.23	59.82	
(Keshalpur)	0.60	30.15	17.72	51.53	1.58

¹ 'The Nature of Coal' *Min. Mag.* of Vol. XXXVI, January, 1927, pp. 16-18.

² The Microbiology of Cellulose, Hemicellulose, Pectin and Gums' A.C. Thayer and H. J. Bunker, 1927, p. 3 (see also p. 222 also pp. 247-248).

³ Analyses by Mahadeo Ram, Geol. Surv. Lab., Calcutta.

The variation in the character of vitrain from different seams, different fields, and from strata of different geological age is seen in the accompanying analyses¹:—

Vitrain from—	Moisture.	Ash.	Volatile Matter.	Fixed Carbon.	Sp. Gr.
<i>Gondwana Coals.</i>					
Karharbari ..	0.84	1.55	36.01	61.60	1.274
Jainti ..	2.42	2.18	33.76	61.64	1.294
Jharia, XVII ..	1.77	3.58	32.54	62.11	1.311
„ Huntodih ..	3.03	1.21	34.8	60.91	1.302
Ranigang, Ghusik ..	5.26	3.27	38.83	52.64	1.30
Karanpura, Argada ..	6.27	1.58	33.95	58.20	1.304
S. Rewa, Burha ..	9.66	3.38	44.30	42.66	1.334
Hutar ..	13.93	0.75	41.75	43.57	1.343
Rajmahal, Mahashpur ..	14.17	1.14	39.59	45.10	1.370
Rajmahal, Pachwarha ..	16.26	2.11	40.36	41.27	1.366

Tertiary Coals.

Assam, Namdang ..	2.04	1.21	42.27	54.48	1.24
Assam, Cherrapunji ..	2.14	2.77	50.38	42.71	1.262
Assam, Borjan ..	4.35	1.95	48.00	45.70	1.304
Assam, Watching ..	8.15	0.39	38.48	52.98	1.328

The increase of specific gravity with increase of moisture content is curious. My attention was first drawn to it by Dr. L. L. Fermor. He is of the opinion that it strongly suggests the colloidal nature of the vitrain.² In this connexion Dr. W. A. K. Christie, too, has found that vitrain is capable of losing moisture and re-absorbing moisture. Dr. Christie, working in Calcutta in April (22-4-28), exposed a piece of vitrain to the sun for 2 hours (noon to 2 p.m.) and then for 21 hours to moist air. He found that the sun-exposed vitrain took up 17 per cent. of its own weight in that time. There is a wide variation of specific gravity even among neighbouring pieces of vitrain in a layer a quarter of an inch thick. Among 10 pieces Dr. Christie found variations from 1.337 to 1.392 at 30 C. by immersion in mixtures of acetylene tetrabromide and xylol for the same length of time. This last condition is important as alterations occur on soaking. For instance, the densest piece of the above mentioned ten, gave an indicated specific gravity one day later of 1.425 (31 C) two days later 1.437 (30 C) and 4 days later 1.452 (30 C). Dr. Christie repeated the experiments using Clerici's (thallium formate and thallium malonate) solution instead and found a range at first from 1.299 to 1.340 (at 29°C) and after 24 hours from 1.399 to 1.457 (at 30°C) in the specific gravity. He next used sodium iodide solution and obtained a range of 1.285 to 1.325 (at 30°C) at first and after a day 1.332 to 1.344 (at 32°C) in the specific gravity

¹ Analyses by Mahadeo Ram, Geol. Surv. Lab., Calcutta.

² *Rec. Geo. Surv. India.*, Vol LX, pt. 4, 1928, pp. 349-350.

of picked vitrain fragments. These results show that the vitrain may be partially dissolved or replaced and that mere absorption has not been the sole factor, so that such data cannot be advanced in support of the colloid nature of vitrain. This does not, however, affect the ratio of volatile matter to fixed carbon which is clearly irregular in the series of vitrains from India. Vitrain, unless the moisture percentage is high, usually possesses strong coking characteristics. The substance (vitrain) is very brittle, and, as a result of its friability, appreciable quantities of vitrain accumulate in the slack or finer coal material. It is for this reason that the slack is both lower in ash and of better coking quality than the normal coal (in India).

3. CONSTITUTION OF COAL.¹

Geologists fully recognise the vegetable origin of coal.²

Coal is a rock. They are, however, chiefly concerned with its economic importance, and study its mode of occurrence, chemical and physical characteristics and, in a distant way, its palæontology. In this last respect they are aware of a general absence of evident vegetable structure and note the unplant-like composition of ordinary coal. To the geologist, therefore, coal is as much a rock as nummulitic or coral limestones are rocks. Consequently they consider coal as a mineral substance. Palæo-botanists, on the other hand, viewing the subject from the point of view of plant preservation, as observed by microscopic examination insist that "coal is a compact, stratified mass of 'mummified' plants (which have in part suffered arrested decay to varying degrees of completeness)...."³ An impartial referee, having regard to the niceties of the meaning of words, and conscious of the fuel value of coal, would probably prefer the word 'metamorphosed' to either 'mineralized' or 'mummified' and would almost certainly substitute the word 'coalification' for the words 'arrested decay.'

We have yet to discover the steps in the change from plant matter, with its cellulose, ligno-cellulose, lignin and suberin to coal, in which none of these compounds are chemically recognisable. There is little doubt that all these compounds are involved in the production of those other compounds which have been extracted from coal. The plant material which is deposited and finally converted into coal consists largely of trunks of trees, branches, twigs, leaves and bark and spores, with their wax and resin content.

¹ Monograph Dept. Sci. Indus. Resch., 1918, M. C. Stopes, p. 1.

² Date Geo. Chemistry, 1920, p. 746.

³ Marie C. Stopes. *Supra*, p. 1.

It has already been mentioned that three visible constituents—*vitrain*,¹ *fusain*,² and *durain*³—Vitrain from bark. have been recognised in ordinary coals in all countries. The variable nature of vitrain, the purest form of the carbon, hydrogen, oxygen and nitrogen complex in coal, has been demonstrated by analyses of Indian vitrain. One of the analyses—Huntodih vitrain—is the vitrainized outer sheath or cortical portion of a flattened tree stem, the interior wood of which has disappeared and been replaced by siderite in which the woody structure is still evident. That the vitrainized portion of a tree stem has a composition very similar to the vitrain from the coal of the same seam is evident from the following proximate analyses of vitrain from XVII seam, Jharia field:—

Vitrain.	Moisture.	Ash.	Volatile Matter.	Fixed Carbon.	Sp. Gr.
Cortical portion of tree stem in roof of XVII seam, Bulliari ..	1.67	3.97	31.24	63.12	1.308
Laminae in XVII seam, Bhagaband ..	1.77	3.58	32.54	62.11	1.311
Laminae in XVII seam, Bhatiagarha ..	1.99	4.09	33.76	60.16	1.330

N.B.—Bhagaband is nearer to Bulliari than Bhatiagarha.

There are thus reasons for believing that the cortical portion of tree stems, converted into vitrain, constitute a large part of the bright coal laminae in XVII seam, Jharia. And, seeing that the presence of bright coal laminae (vitrain) is not peculiar to XVII seam, but characterises most of the Lower Gondwana coals, the probability is that the same component of plant material has supplied much of this vitrain. This *cortical vitrain* is not always of uniform composition as seen in the proximate analyses below:—

Geological horizon.	Moisture.	Ash.	Volatile Matter.	Fixed Carbon.	Sp. Gr.
Bulliari XVII seam (Lower Permian).	1.67	3.97	31.24	63.12	1.308

¹ C. A. Seyler. 'Nature,' April 3, 1926, p. 486.

'The Nomenclature of the Banded constituents of coal.'

A. Duparque. *Soc. Geol. d. Nord Annales*, 1925, p. 56 (1926).

'La structure microscopique des chas bons de Terre les quatre de la Houille du nord de la France.'

² A. E. Bect. *Fuel*, Vol. III, 1924, p. 391: also H. Bode. *Fuel*, Vol. VII, 1928, p. 487.

E. Stach. *Gluckauf*, 63, 1927, p. 759 and *Fuel*, Vol. VI, 1927, p. 403.

³ Marie C. Stopes: On the Four Visible Ingredients in Banded Bituminous coal. *Proc. Roy. Soc., Ser. B*, Vol. XC, 1919, p. 470. See "Nature," Dec. 25, 1926, p. 913, and Oct. 15, 1927, p. 547.

Geological horizon.	Moisture.	Ash.	Volatile Matter.	Fixed Carbon.	Sp. Gr.
Huntodih (Upper Permian).	3.03	1.21	34.8	60.96	1.302
Sutlej (Bhakra) (Upper Miocene).	7.41	3.29	40.38	48.92	1.359
Beas (Amli) (Pliocene).	11.74	2.26	45.50	40.50	1.404

In each of the above four examples the true (inner) wood has disappeared. In the case of the Bulliari and Huntodih specimens, where the stems are in shale in the roof of the coal, the inner wood has been replaced by siderite in which the woody texture is still preserved. In the case of the two Tertiary specimens there is an infilling of sand similar to the sandstones in which the stems occur.

There can be little doubt that the jet like vitrain with its conchoidal fracture is very suggestive of a hardened black jelly. It is therefore not surprising that the idea of a fundamental jelly in regard to the coal substance has existed for the past fifty years since Fremy wrote. I confess that I am in support of such an idea in regard to vitrain which when soft and jelly-like was probably the substance known as *dopplerite*, which is sometimes found as a black jelly in mature peat. (H. Winter *Glückauf Beig und Hüttenmannische zeitschrift*, 1922, 58, 1533-1529, 5 fig).

It is a curious fact, so far as my field observations go, that when an embedded tree stem occurs with its outer sheath (or cortical and bark portion) attached the inner wood (within the cambium layer) is not carbonized. It either disappears entirely when the stem occurs in porous (permeable) sandstone or is replaced by siderite, if the tree is embedded in impervious shale. On the other hand if the true woody stem or trunk occurs without its outer bark or cortical sheath and is embedded in permeable sandstone the wood substance alone disappears but is replaced by silica in which the woody texture is often beautifully preserved. These silicified logs are common in certain horizons in the Tertiary rocks of Burma, and are by no means uncommon in the Damuda (Permian) sandstones of the Jharia coalfield.

In one case found by Mr. E. R. Gee, the woody part of a stem, with no attached outer sheath of bark or cortex, was embedded in impervious Jurassic shales (Sakesar, Punjab Salt Range). In this instance the wood has been carbonized into dull black lignite of the following proximate composition:—moisture 8.27 per cent., ash 0.94 per cent., volatile matter 52.61 per cent., and fixed carbon 38.18 per cent. The specific gravity

¹ 'The Constitution of Coal': M. C. Stopes and R. V. Wheeler, *Dept. Sci. Indus. Res.*, Mon., London 1918, p. 3.

was 1.223. The appearance of this true fossil wood (with the structure well preserved) is interesting. It has a fine, fibrous, dull-satin lustre when viewed perpendicular to the length of the stem, and a dull, finely granular texture when examined end-on to the stem. It takes a bright polish not unlike vitrain.

An examination of specimens of *fusain*¹ shows that there are different varieties. One, the typical fusain of coal petrologists, has a fine fibrous structure and contains soft, silky, separable fibres, which soil one's hands with powdery carbon. Another, has stiff, non-separable fibres, very suggestive of some charcoals, which barely soils ones fingers when handled. Both materials have a fine to distinct granular texture when viewed end-on to the fibres. And there is little doubt that these varieties merge into material similar to the carbonized wood from Sakesar.

Fusain generally escapes notice on faces of coal vertical to the lamination, but it is easily recognised on the flat surface bedding of the coal. The thicknesses of fusain laminae are often greater than are first gauged in a casual glance. And there is a close association of fusain with vitrain. These two constituents are seldom found apart. Usually laminae of fusain and vitrain are in juxtaposition on one side or the other of a layer of vitrain. There is every reason to believe that the fusain in most Indian coals is the carbonized wood of plants. Its constant association with vitrain suggests that it is the carbonized woody part nearest the cortical sheath (which is also present, in carbonized form, as vitrain). The nature of the powder of typical fusain, its streak and composition, supports the opinion that free-carbon is present in fusain.

Although it is the expressed opinion, of many distinguished investigators of the origin of coal, that fusain is true charred wood—the result of forest fires before the plant debris was deposited—I find no convincing evidence from my field observations in support of such a view. On the other hand I would draw attention to the fact that while fusain is conspicuous in the older (Palaeozoic) coals, it is less evident in the Mesozoic coals, and distinctly rare in those Tertiary coals which have not been subjected to considerable tectonic pressure. In the newer coals, such as the fossil wood from Sakesar, the cells and spaces between the woody fibres appears to be permeated by vitrain. It is conceivable that under great pressure more heat may be generated in the vitrain of these cell infillings of the

¹ It has always been admitted that fusain is formed from the wood of plants. Typical fusain shows the carbonized woody fibres coated with carbon. If the fibres were coated with or embedded in vitrain the appearance of the specimen would resemble the wood found by Mr. Gee near Sakesar.

true wood than in the vitrain of the cortical sheath of a stem. As a result a greater degree of carbonization would ensue which might easily reduce the original infilling of vitrain to the condition of graphitic carbon.

The outer or cortical material and the inner or true wood Durain—a mixture. (within the cambium layer) of course, do not represent all the plant material which has been converted into coal. Some leaves, when found in carbonized form, are represented by very thin laminae of bright coal, indistinguishable from vitrain. I have not been fortunate enough to secure enough of this type of bright coal to be able to investigate the matter fully. In view of what has been said it would appear that we must look for the other plant parts, small stems and twigs, leaves and spores, and the debris of these materials, in the dull or durain laminae of coals. When the durain is uniformly dull and fine textured, the evidence is suggestive of it being composed of the finest materials of plant debris. When the durain is streaked with thin laminae of bright coal the conclusion is that it is constituted of stems and leaves and other relatively larger plant fragments. The deduction is that the durain must also contain the sporangia and macrospores and similar plant parts of an indestructible type. These cannot be recognised in ordinary hand-specimens without the aid of a microscope. The method of investigation adopted is to examine polished surfaces or thin sections of coal under the microscope. These studies show that the resins and waxes, including recognisable sporangia and spore-bodies, are largely concentrated in the dull coal (durain) layers.

Practically all microscopic investigation of coal has till recently been carried out by palaeobotanists, who normally only use ordinary reflected or transmitted light for their scrutiny of polished surfaces or transparent sections of coal. My investigation of thin sections of coal by the methods ordinarily followed by petrologists, *i.e.*, using plane polarized light, was evidently the first application of the method.¹ I found that the whole of each of the coal slices examined appeared to be permeated by some substance of remarkable optical uniformity—irrespective of the presence of recognisable plant structures. This coal-substance, when thin sections are viewed perpendicular to the plane of lamination of the coal, behaves as an isotropic mineral. The section remains dark between crossed

¹ 'Nature' Dec. 25, 1926, p. 913 and Oct. 15, 1927, p. 547.

There are numerous papers on the microscopic examination of coal. A very good bibliography of these paleo-botanical studies is given in Dr. Erich Stach's book (1928)—*Kohlen petrographisches Praktikum*—published in Berlin. See also Dr. J. G. Kellett's paper—"The physical constitution of Bituminous coal and coal seams" in *Trans. Inst. Min. Eng.*, Vol. LXXV, Pt. 5, 1928, p. 400-412.

nicols. In the case of sections cut vertical to the plane of bedding, this substance exhibits the properties of a uniaxial mineral. The material gives straight extinction parallel to the lamination. In both types of section the entire permeating substance in the field of view is seen to be in optical continuity. I was forced to the conclusion that the pervading substance, which constitutes most of the material in all the coals examined, is probably colloidal matter in a state of strain. It is clearly of great mineralogical uniformity. The uniaxial character, attributable to strain, has possibly been caused by the pressure to which the coal has been subjected as a result of the weight of the superincumbent strata.

The vitrain portions of the slices are always the most transparent. Their colour in normally thick sections is a red madder. In thin sections in strong illumination the material has a fine gold yellow colour. The macrospores and other resinous bodies have a bright gold colour. In some cases, *i.e.*, the sheaths of sporangia, the colour is a rich red. I am unable to say if the difference is due to natural staining or to a difference of material or to curious optical phenomena. The resinous bodies and the walls of macrospores exhibit anomalous dispersion when rotated between crossed nicols—the brushes of the rotary dark cross being clearly evident. The fusain is invariably opaque, with the cell-spaces usually lined with powdery carbon or filled with inorganic crystalline matter—calcite, siderite, etc. The clay and metalliferous impurities, generally restricted to the durain are as usual opaque and the pyrite or marcasite can be recognised by its brassy colour in reflected light. The presence of cellular or other structure and of spore-like bodies is less frequent in the clearer laminae of vitrain than in the dark bands of the durain. In the latter the resinous bodies are sometimes abundant, and so also is the inorganic material which forms the ash. These resinous bodies have not been found in typical fusain.

The coals examined range from English Upper Carboniferous bituminous types to the Permian (Gondwana) coals of the Indian Peninsula and the lignitic Tertiary coals of Assam and Baluchistan. In most of these the characteristics already mentioned are observable and include the bright gold sections of macrospores, the red and gold resinous bodies and the opaque inert matter of clay and pyrite, in the durain and the dark cell-structured patches of fusain. These latter (fusain patches) are not conspicuous in the Tertiary lignitic coals—presumably the de-volatilization of the wood has not proceeded far enough. The material of which the spores and cell-walls are composed is chemically very resistant. These clearly recognisable plant parts are embedded in the ground mass of the uniform coal-substance, which is indistinguishable from and is considered to be vitrain in each of the sections examined. A woody structure

of some kind is seldom absent even in the clearest patches of vitrain. It is probably the structure present in the cortical material.

The fact that proximate analyses show the vitrain from different classes of coal to be dissimilar in composition is thought to be evidence that the quality of the coal depends to a considerable extent on the degree of devolatilization to which the vitrain has been subjected. The loss of volatile matter is ascribed to the heat generated within the coal by the pressure of the superincumbent strata or the tectonic squeeze due to folding. These aspects of pressure are well-known under the title of Hilt's law. This, and the fact that vitrain absorbs and loses moisture, possibly within certain limits of temperature, support the opinion that vitrain may be present in colloidal (gel) form. Although the molecular structure of vitrain must be complex, there is no doubt, from the optical data, that its physical characteristics indicate a substance of considerable uniformity.

The different degrees of de-volatilization, which characterize the vitrains from different classes of coals, cannot be due to bacterial activity. Tracing back the vitrains by their lesser and lesser degree of de-volatilization to a primary vitrain relatively high in volatile matter, it seems inconceivable that a substance of such uniformity could have been evolved except by chemical action. It also seems certain that, operating with plant material of recognised remarkable uniformity of composition, the primary vitrain is probably the same substance in all cases. The probability is that all primary vitrains are identical, and that these vitrains represent the dark hardened form of the gelatinous substance, occasionally met with in mature peat bogs, known as dopplerite.

The dopplerite from Raubling, according to H. Winter (*Glückauf*, 58, 1922, p. 1535) has the following ultimate composition:—

Carbon 56·93%, Hydrogen 5·30%, Oxygen 36·88 (plus Sulphur %, and Nitrogen 0·89%. It is supposed to consist essentially of ulmins. It is completely soluble in caustic alkalis, and slightly soluble in organic solvents. Its colloidal nature is presumed from its absorption and retention of water. These characteristics greatly resemble vitrain, particularly since dopplerite yields 50% of volatile matter on coking.

4. THE FORMATION OF INDIAN COALS.

It is possible to accept three important factors in regard to coal formation. These are—(1) that the processes of coal formation have been repeatedly operative since Cambrian times; (2) that the composition, at least of terrestrial plants, whether of low or high organization, has remained remarkably uniform

since the Palaeozoic period ; and (3) that the fundamental coal-substance, when freshly formed, has possibly been identical in all ordinary coals, and that it is a colloidal substance, capable of change in composition under the influence of heat (generated by pressure) and, able to lose and re-absorb moisture on exposure. It appears to be the product of the chief components of plants—cellulose, lignin and suberin—which have been successively chemically broken down to form a common jelly, which, by subsequent hardening to primary vitrain, and subsequent change by de-volatilization, is preserved as pure vitrain. The quality of the vitrain, is some measure of the degree of maturity attained by a coal in its metamorphosis towards pure anthracite.

The evidence indicates that the processes of the conversion of vegetable matter into coal have followed definite chemical changes and is fundamentally due to these chemical changes unaffected, to any appreciable extent, by the vagaries of fungal or bacterial activity.

The following interesting extract has been made from "The Microbiology of Cellulose, Hemicellulose, Pectin and Gums" (by A. C. Thayser and H. J. Bunker), 1927, pp. 247-248:—

"It is not difficult to contemplate conditions under which vegetable material will decay under water-logged and more or less anaerobic conditions. The preparation of silage offers a very good illustration of such conditions, though the microbiological decay in this case undoubtedly proceeds under more favourable conditions than during the formation of peat, especially as regards range of temperature and presence of a more or less readily decomposable plant material...it has already been pointed out that fully ripened silage, in which all microbiological activity has ceased, still contains large quantities of cellulose....if micro-organisms are unable to complete the destruction of cellulose during silage fermentation, are they likely to do so during the decay of the heterogeneous material which is deposited in a peat bog? Is it possible, it may even be asked, that their activity can carry the decay as far as in the silage fermentation under the comparatively unfavourable conditions existing in a peat bog, where both the peat itself and the water in which the vegetable debris becomes submerged have been found to check the development of micro-organisms?"

The conversion of plant matter into coal appears to have been conducted in all cases under water, under anaerobic conditions. These conditions were evidently eminently suited to the preservation of the submerged plant structure. It follows that the processes of conversion of vegetable matter into coal have been exceedingly slow, measured in years. The conditions were, from the evidence in the production of silage, clearly fatal to the existence of plant life, and bacterial activity

is thought to have ceased at no long period after the submergence of the plant debris. Such conditions are against the view that the plants debris which was converted into coal, actually grew on the spot where they were finally deposited, however near their site of growth may have been to the place of deposition. The *Stigmaria* and *Sigillaria* stems found in coal seams of the Joggins field in Nova Scotia certainly provide evidence that these trees grew on the sites on which the coal was formed, but they do not prove that they provided the plant material which was converted into coal. The trees clearly died as a result of the submersion of the land on which they grew and vegetable matter was deposited in the water in which the tree stumps stood. That is all that can be said. The plant debris was brought (floats) in from very near or very far.¹

The processes of conversion into coal were not fundamentally affected by the plant matter being immersed in fresh water rather than salt water. In the latter case there is a curious but definite occurrence of petroleum in association with the marine coal, which may be due to the presence of a marine flora or to some other cause not yet understood. It is a fact that most marine coals contain more sulphur, and are associated with pyritiferous strata to a greater extent, than is the case with coals of fresh water origin. We have yet to learn the significance of the effects of acid and alkaline waters in connection with the conversion of plant matter into coal. It is thought that the former in weak solutions, generally, has a preservative effect although fatal to actual life, and that weak alkaline solutions promote the processes of conversion or coalification.

Speaking in a strict stratigraphical sense, the top of each coal seam marks a stratigraphical 'break.' This is particularly true of the seams in the Jharia coal-field. Here pebbly sandstones, sometimes with the boulders themselves, rest on the coal. These covering beds are current-bedded in such a manner that successive layers overstep each other on to the coal. Such examples show that a marked change took place—from the quiet, relatively deeper waters, in which the maturing vegetable mass lay, to the turmoil of a river in flood. A careful scrutiny of such junctions, between the coal and the roof stone, show that the coaly matter was already quite firm before it was covered by later sediments. Complete conversion into coal appears to have already been accomplished before the over-

¹ J. W. Dawson. "On the Conditions of the Deposition of Coal." *Q.J.G.S.* Vol. XXII, 1866, p. 95. See also J. Beete Jukes. "Geology of South Staffordshire coalfield." *Rec. School of Mines*, Vol. I, pt. 2, 1853, pp. 320-321. I am quoting old papers because in those days the field examinations were exhaustively carried out unhurried by the pressure of other engagements so common today.

lying strata were deposited. Some pebbles resting on the coal are coated with coal and no such pebbles have either sunk into the coal or are deeply embedded in it. In other cases pebbles are found with their coal contact surfaces corroded—evidently by subsequent percolating alkaline waters, since the pebbles were originally smooth and rounded and are of quartzite. In several cases the mine water in Indian coal mines is found to be alkaline, and not acid, and this in spite of the fact that the coal contains pyritiferous matter and the water deposits limonite from the solution when exposed to the air.

There is no doubt at all that the fresh water and marine coals of India were formed under water in regions subject to prolonged subsidence.

Deposits in areas of prolonged subsidence. The deposition of the Damuda series involved upwards of 6,000 feet of coal-bearing strata, and necessitated subsidence throughout the Permian period—of 12 to 15 millions years duration¹. One foot of sediment in 2,000 years is a slow rate of uniform deposition under fluvial conditions. The presence of successive beds of pebbly sandstones, followed upward by shales and succeeded by coal seams, shows that the sedimentation was not uniform, but we have no evidence in the Raniganj field, the type area of these deposits, that the pauses involved the sediments being exposed to atmospheric weathering. The data merely point to a slowing of the velocity of the rivers and periods of relative stagnation when the plant debris settled down. The plant debris appears to have remained submerged throughout. I have stated before that the sandstones are markedly current bedded; that some coal seams pass laterally into shales; and that single seams split up into one or more seams when traced in a particular direction. These are evidences of fluvial deposition.

The above features are not so clearly seen in the case of the marine (Tertiary) coal-bearing strata of Assam and Burma, on the one hand, and of the north-west of India, on the other. The evidence from these Tertiary coal-fields is that the plant debris, again largely of terrestrial flora, was deposited in the stagnant waters of lagoons bordering deltas or at the head of a gulf. It is known that these regions were undergoing subsidence in Tertiary times at the time of the deposition of the coal-bearing strata. It has been pointed out that the Eocene coals of the north-west, and the Salt Range of the Punjab in particular, are overlaid and underlaid by carbonaceous, pyritiferous shales in a conformable manner. These

¹ The era of the Gondwana System covered a length of time equal to 70 million years on the basis of Schuchert's Time Scale (*Historical Geology*, pt. 2, 1924, p. 105). The maximum thickness of the upper and lower Gondwanas did not exceed 21,000 feet in total. This gives one foot of sediment in 3,300 years which is exceedingly slow for fluvial deposits.

black shales are rich in the fossil remains of foraminifera and other fauna—adventurous little bodies in deadly waters. Judging by the pyritic character of the beds, the plant material must have accumulated in distinctly acid (sulphurous) water—probably excellent for the preservation of plant structures but fatal to animal life. Higher in the succession of strata there are massive nummulitic limestones which indicate the deeper clearer waters of an open sea.

In the case of the Bikanir lignite, which failed to be converted into coal, the stratigraphical record is in general similar to that of the Salt Range but with this very important difference. There is a well-marked stratigraphical “break” at the top of the lignite horizon. The lignite had been subjected to erosion in Eocene times and was then directly overlaid by the nummulitic limestone. The lapse of time indicated by the “break” is, geologically speaking, not large, since the strata above are of Upper Eocene age—a duration of time equal only to a phase of Middle Eocene sedimentation. Measured in terms of normal time the pause may represent the lapse of centuries. The absence of coarse sediments suggests that the cause of the erosion of the lignite was due to exposure to atmospheric weathering, while the presence of the overlying limestone indicates a relatively sudden re-submersion—in the clear waters of the nummulitic sea. The result of this believed exposure to atmospheric conditions appears to have been that the lignitic mass was so affected (oxidised) that the processes of coalification ceased. In spite of the subsequent return to submerged conditions the processes were not able to continue and we find lignite today in Bikanir among strata which in adjoining regions contain coal.

We are confronted with the questions—Does coalification take place after the plant debris, as peat or brown lignite, has been overlaid by sediment? and—Does the conversion proceed less rapidly in sea water than in fresh water? There seem to be converging evidences that the conversion must take place relatively quickly in terms of geological time. There is no doubt that modification of the newly formed coal takes place long after further sedimentation as a result of pressure and tectonic squeeze. It appears evident that once the plant debris or the peaty-lignite, and perhaps also the coal, is exposed to the air (to oxidising influences) the processes of metamorphosis or coalification cease for ever. We have little actual knowledge of the part alkaline solutions play in the formation of coal, but judging from the high gypsum content of the ash in Bikanir lignite (evidently due to the reaction between lime-bearing water from the limestone and the pyritic content of the lignite) that these influences are ineffective—at least if the lignite has previously been ex-

posed to atmospheric weathering. On the other hand, judging by the carbonization of wood to black lignite as in the case of the Jurassic material from Sakesar (Punjab Salt Range), and the data produced recently by Dr. E. McKenzie Taylor in regard to the formation of fusain as a result of the effects of *base exchange* in the soil,¹ there is reason to believe that alkaline solutions may have a strong carbonizing action on entombed peaty material. The corroded quartzite pebbles from the roof of XII seam in the Jharia field, and the definitely alkaline character of the mine water from pyritiferous strata associated with the coal of Borjan (Assam), in spite of the fact that the water deposits limonite from solution, show that alkaline waters are associated both with fresh water and marine coal seams.

5. CONCLUDING REMARKS.

From the facts in my possession, of observations made in the various coal-fields, and a careful perusal of the literature on coal formation generally, I am led to the conclusions enumerated in the following summary:—

1. The primary material from which ordinary coal is formed consists of the debris of land plants—logs, roots, branches, twigs, leaves, spores, etc., whose chemical composition, considered in terms of an ultimate analysis, as carbon, oxygen, hydrogen, and nitrogen, is remarkably uniform, and has been so in past geological ages since the Palaeozoic era.

2. The terrestrial plant material—leaves, dead twigs and trunks, etc., was rapidly submerged in fresh or salt water, and finally settled down in the stagnant, aseptic waters of swamps or lagoons. These conditions were evidently fatal for the continuance of plant life, but highly preservative of the plant structures.

3. The attacks by fungi and micro-organisms, however active in the plant material before and during the shallow stages of immersion, are considered to have ceased as the maturing mass sank in deeper water or was covered by further plant debris. It is thought that the fungi attacked the cellulosic components—the sap wood and medullary rays of the higher plants—at a time when damp, aerobic, rather than water-logged, anaerobic, conditions prevailed.

4. The attack of micro-organisms (bacteria), judging from the behaviour of matured silage, cannot have been long continued in the submerged plant material in the relatively aseptic waters which appear to have permeated the peaty mass. It is

¹ E. McKenzie Taylor. "Base Exchange and its bearing on the origin of Coal." *Fuel*, Vol. V, 5, 1926, pp. 195-202, also see Vol. VI, 8, 1927, 359-367, Vol. VII, 2, 1928, 66-71; VII, 3, 1928, 127, 129, 130; VII, 5, 1928, 227, 228, and 230.

possible these conditions were more severe, and that the gelatinization of the cellulose components of the maturing peat, was quicker in sea water than in fresh water. This is credited to the acidity due to the sulphur compounds which appear to have been present, and which, as pyrite, characterize marine coals generally.

5. The main processes in the maturing of peat and its subsequent conversion into primary coal are considered to be of a chemical character and involve all the plant components—cellulose, hemicellulose, lignin, lignocellulose and suberin.¹ It is believed that all these substances are not different chemical compounds but largely mixtures of cellulose with lignin and fatty compounds. These substances, however durable in themselves to chemical attack, are, in the conditions involved, slowly incorporated in changes which result in the production of a gelatinous substance (a complex colloid) of the nature of or identical with dopplerite.

6. The other parts of plants—spores, sheaths of sporangia, the walls of wood-cells, etc., which appear to be indestructible or particularly resistant, are not involved in the production of the black, dopplerite jelly. They remain embedded in the gelatinous mass and are responsible for the recognition of the plant structures observed in coal. All the cellular spaces—wood cells, etc., are, in newly formed coal, filled with the jelly. In spores, etc., the body is composed of resinous matter.

7. The appearance of the gelatinous substance, which presumably permeates the matured peat layer, is accompanied with the elimination—measured in percentages of the original plant substances—of water, oxygen, hydrogen, nitrogen and carbon in the form of various gases. The whole mass at this stage slowly suffers transformation into primary coal or black lignite.

8. The hardening of the gelatinous substance takes place slowly under water, but is evidently accelerated by alkaline solutions. In many instances it appears that the hardening had been accomplished before the overlying sediments were deposited. In its hardened form the pure gelatinous material is thought to be primary (colloidal) vitrain. The darkening which is associated with the hardening is ascribable to de-volatilization.

9. The cellular structure of wood and other plant sections remain unobliterated in the primary vitrain. Where the vitrain has its purest development and least internal structure it appears to occupy areas of original cortex fragments and is easily recognised in the bright laminae of coal. Where cell structure

¹ The details given by Dr. Franz Fischer at the Bituminous Coal Conference sitting at Pittsburg in 1928 were in support of the chemical conversion of cellulose into coal in his experimental work.

is evident the vitrain is an infilling in what was true woody material and is not readily recognised as vitrain in hand specimens. In the laminae where much earthy matter has settled or the plant material was very finely broken up, the vitrain is not so evident.

10. With the deposition of further sediment and the loading of the primary coal a new series of changes begins. The primary vitrain suffers carbonization, accompanied by the expulsion of water, methane, and other gases. This de-volatilization process is due to the heat generated by the pressure on the primary vitrain. With additional pressure the heat continues to de-volatilize the vitrain until the stages of vitrain in bituminous coals are passed and an anthracite is formed. If the pressure and heat are great the cell and other plant structures are distorted and almost entirely obliterated.

11. The temperatures attained in the production of anthracitic vitrain have been estimated at from 450 to 500 degrees Centigrade.¹ At this stage practically 75 per cent. of the volatile components are expelled. The resinous bodies appear to have disappeared also, and the inert constituents become conspicuous if present in appreciable amount in the original peaty mass.

12. It is presumed that in all these processes the material has remained below ground-water level under anaerobic conditions. The several stages in the de-volatilization of primary vitrain are thought to correspond to the several classes of coal ordinarily met with. These must obviously grade insensibly from one to the other, being modified only by the prevalence of one or other accessory such as spores, oily substances or inert matter (water and clay, etc.).

13. The disappearance of the vitrain from within the cavities of the wood cells and between the fibres and the appearance of fusain is possibly due to excessive heat—the result of catalytic action in these capillary spaces. Lenticles of severely carbonized woody material, the well known mineral-charcoal or fusain, are always found more abundantly in the palaeozoic coals. This material contains free carbon in a fine powdery condition, possibly in minute flakes. Free carbon must occur for the same reasons in those scattered wood fragments which are a part, with other comminuted plant debris, of durain. There is probably little free carbon in lignitic types of fusain and probably considerable amounts in anthracitic vitrain.

14. Although vitrain is probably a complex, colloidal constituent, chemically, it has physical properties which suggest great uniformity of substance—particularly in the same coal-seam of a given locality—if the seam has not been disturbed by

¹ "Coal Carbonization" by John Roberts. Chapter II, The origin of anthracite (pp. 9-35), 1927.

igneous intrusions or tectonic forces. It is probably similar in the same class and condition of coal. An exact grading can bring the phases of a classification into use for comparing the degree of carbonization a coal has undergone.

15. The specific gravity of vitrain increases from about 1.2 in lignitic (dry, ashless) vitrain to over 1.4 in anthracitic (dry, ashless) vitrain. Contained water (moisture) increases the specific gravity of vitrain of all degrees of de-volatilization. The specific heat of vitrain decreases from the lignitic to anthracitic types from about 0.4 in the former to 0.2 in the latter on a dry, ashless basis. Increase of moisture increases the specific heat of all vitrain. It is well-known that the heat conductivity of coals in general is low—a hard sandstone probably has ten times the conductivity of normal bituminous coal.¹

16. Vitrain is the chief caking constituent in normal coal. An anthracitic vitrain has weak caking properties. A high percentage of 'contained water' (moisture) in vitrain indicates loss of caking character. By adding hydro-carbons to anthracitic vitrain or by suitably de-hydrating high moisture vitrains it is possible to secure a caking character in such vitrains. The pure vitrain in coal is thus the fundamental substance in that and all classes of coal.

¹ "The Specific Heat of Coal" G. Coles, *Trans. Inst. Min. Eng.*, Vol. LXVI, 1923-24, p. 327, see also *Jour. Soc. Chem. Indus.*, XLII, 1923, pp. 435T-439T.

"The Possibility of Spontaneous Combustion being initiated by the Heat produced by crushing": H. Briggs, *Trans. Inst. Min. Eng.*, Vol. LXIV, 1922-23, p. 233.

Section of Geology.

Abstracts.

1. Lateritisation of Khondalite.

M. S. KRISHNAN.

A series of nine analyses of Khondalites ranging from perfectly fresh rock to those in which the alteration has resulted in bauxite, are studied. Except one, which comes from Ceylon, all the specimens come from Kalahandi State.

The fresh rocks show the presence of quartz, (sometimes felspar), garnet, sillimanite, and graphite. When decomposed, they give rise to lateritic material. An examination of the analyses reveals the fact that, early in the process of decomposition, the oxides of the bivalent elements get eliminated, the percentage of silica diminishes, while water, ferric oxide and alumina increase progressively. The end-product is usually a bauxite, in which alumina is found together with some ferric oxide and silica. Titania also tends to get concentrated in the decomposed rock.

On plotting the two chief groups of oxides *i.e.*, the trivalent and univalent, it is seen that the proportions of the former to the latter vary between 2.5: 1 and 4.5: 1; at the bauxite end, the proportion is roughly 2.5 or 3: 1. This lends support to the suggestion of Dr. Fox (in his Bauxite Memoir) that in aluminous laterite, the alumina (plus iron) content can be roughly estimated by multiplying the water contents by 2.6.

2. A trachyte from Salsette Island, Bombay.

M. S. KRISHNAN.

A specimen of a light creamy coloured rock from the Kharodi quarries in Salsette, when examined under the microscope, is seen to be fine grained and composed of orthoclase, oligoclase and some quartz. Calcite and pyrite are present in small quantities, the former being probably secondary. Some decomposed pyroxene is also present. A quantitative analyses shows the following constituents:—

	per cent.			
SiO ₂	81.54
TiO ₂	Trace
Al ₂ O ₃	15.82
Fe ₂ O ₃	0.26
FeO	3.79
CaO	3.36
MgO	Trace
K ₂ O	4.61
Na ₂ O	6.21
H ₂ O (—)	0.24
H ₂ O (+)	1.59
P ₂ O ₅	0.71
CO ₂	0.96
FeS ₂	1.70
TOTAL ..				100.73

The rock is quite a popular building stone in Bombay with a pleasing appearance and a crushing strength of 1531 tons per square foot. The

'Gateway of India' has been built of this. Its defect, however, lies in the presence of pyrite and calcite, the former decomposing to sulphuric acid and ferric hydroxide, and the latter giving rise to gypsum. The ferric hydroxide produces patches of browns and yellows; Gypsum, when once it begins to form, will tend to grow along cracks and in bunches, weakening the rock.

It is therefore suggested that much care should be exercised in selecting the stone at the quarries with the minimum of the deleterious minerals, particularly if it is to be used for the construction of valuable monuments.

3. The Niniyur stage.

L. RAMA RAO.

After giving a brief account of the lithological and palaeontological characteristics of the beds round about Niniyur, Sainthoray, and Yellakudumbur, they are shown to form a distinct stratigraphical unit—to which the name Niniyur stage has been given. Overlying the Ariyalur beds, these fossiliferous beds of the Niniyur formation are considered, for reasons mentioned in the paper, to have been deposited during a post-Senonian transgression of the sea in this area. From the palaeontological evidences, both internal and external, the homotaxial relationships of this formation have been worked out, and evidence is put forward to indicate that the two important subdivisions of this formation—the lower (*Gryphea-Cardita* beds) and the upper (*Nautilus-Lucina* beds) are respectively equivalent to the Maestrichtian and the Montian sub-divisions of the Danian in Europe.

4. Note on the occurrence of Sulphur in some of the tertiary coals of India.

N. CHATTERJEE, Calcutta.

The writer carried on investigation with a series of tertiary coals of Western India. The coal samples supplied to him by Dr. Fox are from Palana, Mach, Jammu, and Dandot. The author has determined the amount of Sulphur as also its mode of occurrence in them. From the results of analyses it is shown that the anthracitic coals contain very small amount of Sulphur as compared with other coals of the series. The writer thinks that on account of the Metamorphism the percentage of volatile sulphur is very low in the anthracite coal. The author has discussed the importance of determining the mode of occurrence of sulphur from an economic standpoint.

5. Action of solvents on Indian coal, No. 1.

N. CHATTERJEE, Calcutta.

The Author of this paper is engaged in the study of the action of Pyridine and Chloroform on various types of Indian Coal to get an idea about the amount of Cellulosic and Resinic constituents present in them as well as their other relationships e.g., coking properties. The present paper deals with a series of tertiary coals of Western India, all belonging to the Laki stage. The specimens were very kindly supplied by Dr. Fox. The writer has described the preliminary and experimental methods adopted by him in the laboratory and the results of his experiments have been enumerated with some observations. The work is still in progress. From the result obtained it is shown that the β and γ compounds are nearly absent in the Jammu anthracite whereas they are present in appreciable quantity in other coals of the series.

6. Sedimentation in Panchet epoch.

SETHU RAMA RAU.

The rivers transporting the sediments during the Panchet epoch in all probability flowed from the south to north as tributaries of the main river. The angular shape of the felspars embedded in the grits, with the subangular pebbles of vein quartz, point to the deposition of sediments being not far away from the original rock. The irregular pebbles and boulders of biotite quartz gneiss and flaggy quartzite embedded in the conglomerate of the Panchet rocks could not stand transportation over a long distance on account of their fragile nature and should have been deposited quite close to the source. The requisite amount of iron for the colouring matter of the red clay, ferruginous cement of the conglomerates, and hematitic bands, could probably have been obtained from the decomposition of garnets and biotite, from the biotite gneisses and garnetiferous schists which are abundant in the crystalline rocks exposed in the south of the coalfield.

Rocks occurring north and south of the coalfields are similar and might have supplied similar sediments. The tributaries carrying these sediments, to join the main river whose direction of flow is doubtful, might have flowed either from the south to north or *vice versa*. But the gradual passage of sediments from a coarser type in the south to a finer one in the north suggests, that the tributaries were flowing from the south towards north.

7. Evidence of tectonic shearing in the Raniganj and Jharia coalfields.

SETHU RAMA RAU.

An examination of the southern portion of the Raniganj coalfield shows, that the strata near the crystalline boundary are folded into a series of successive anticlinal and synclinal folds. Similar structure is observed in the Jharia field also, but the folds are more squeezed. Such folding might have been produced by lateral compression of strata, caused by horizontal and tangential pressure, which was exerted at different times.

As the beds corresponding to the Triassic are affected by folding, the compressive forces should have acted in post-Triassic times or early in the Jurassic period.

8. Some geographical observations in Western Tibet.

S. R. KASHYAP, Lahore.

The writer visited Western Tibet in 1922, 1923, and 1926. The observations described in the paper refer to the journeys of 1922 and 1926.

In 1922 he entered Tibet from Kumaon by the Lipu Lekh pass, visited the holy lakes, Manasarowar and Rakastal, went round the Kailas mountain, then travelled west to Gyanima and the large monastery of Tholing, and came back through Garhwal *via* the Mana pass. In 1926 he entered Tibet by the same pass, visited the holy lakes and the holy mountain, went round the holy mountain, travelled west through Dulchu and Tirtha puri, and returned by the Kungri Bingri pass. In addition to the collection of plants made in the country the following geographical observations are of interest:—

1. On both occasions the much-talked of channel between the two lakes was dry. He was, however, informed by reliable people who had been actually on the spot in 1924 and 1925 that in both these years the channel contained water flowing from the Manasarowar to the Rakastal lake.

2. The only European writer who has described the circuit round the Kailas from his personal observations is Sven Hedin. His description of the northern side is inaccurate. For instance, the distance from the pass (measured from the huge stone with the flagpoles) to the Gaurikund lake is 775 feet, and from the end of the pass only 600 feet, along the road. Sven Hedin states that the pass is 4 km. west of the lake. Similarly other statements are inaccurate.

3. The temperature of the two main hot springs at Tirtha puri was 69°C. just below the opening. It was surprisingly constant.

4. On the way back through Johan (1926) the Himalayan range has to be crossed by three passes in one day. The altitudes of these passes as given by Sherring are as follows:—

Kungri Bingri	18,300 ft.
Jayanti	17,000 ft.
Unta Dhura	17,590 ft.

The boiling point observations as taken by the writer on the tops of the three passes were as follows:—

Kungri Bingri	82° C.
Jayanti	81° 8 C.
Unta Dhura	82° 5 C.

It will be seen from the above that the Jayanti is the highest and not the Kungri Bingri.

9. On a new Theropod dinosaur (*Orthogoniosaurus Matleyi* n. gen. et n. sp.) from the Lameta beds of Jubbulpore.

H. C. DAS-GUPTA, Calcutta.

A short description of the tooth which is found to be related to the Cretaceous *Coelurus gracilis*. The Indian Triassic *Epicampodon* (= ? *Thecodontosaurus*) *indicus* may be regarded as a very close ally of *Orthogoniosaurus Matleyi*. The new genus has been placed under the family of *Anchi sauridae* (*Thecodontosauridae*).

10. Notes on the genus *Titanosaurus*, Lyd.

H. C. DAS-GUPTA, Calcutta.

The scapula of *T. indicus* and the humerus, ulna, sternum, ischium, pubis, femur, tibia, metatarsal and first caudal vertebra of *T. Blanfordi* are described. The close relationship between *Titanosaurus* and *Cetiosaurus* as pointed out by Lydekker is confirmed. The characters attributed to the family of *Titanosauridae* by Baron von Huene are discussed and attention is drawn to a few points wherein a different opinion may be held.

11. A preliminary note on the Anorthosite near Ranigunj, Bengal.

S. C. CHATTERJEE.

The paper embodies the results of the study of the Anorthosites and the associated Norites and Granite-Pegmatites occurring along the southern boundary of the Ranigunj coalfields.

Three types of Anorthosites are distinguished and the detailed microscopic and chemical characters are given. The peculiarities and the field characters are discussed with reference to the prevailing views concerning the origin of the Anorthosites and it is pointed out that the Ranigunj occurrence can be very well explained by accepting the ideas of Miller regarding the origin of the Anorthosites.

12. Crystallographic notes.

S. L. BISWAS and B. MAITRA, Calcutta.

Description of—(1) A specimen of Quartz from Singbhum showing a clear crystal formed over a nucleus which exhibits the same type of symmetry as the enclosing crystal. (2) A crystal of Cassiterite from Hazaribagh—showing forms (111) and 101.

13. The Influence of roof conditions on the Bacterial Decomposition of organic matter with special reference to the Formation of Coal.

E. MCKENZIE TAYLOR.

The results of the examination of the roofs of bituminous coal seams may be summarised as follows:—

(1) It has been established that the roofs of bituminous coal seams irrespective of geological age, have undergone base exchange with solutions of sodium chloride and that the sodium clay thus produced has been hydrolysed subsequently in freshwater. They contain sodium clay similar to that in an alkaline soil.

(2) The roofs of bituminous coal seams could supply, as the result of hydrolysis, an alkaline medium under anaerobic conditions for the bacterial decomposition of organic matter.

It will be seen that the Indian specimens examined agree in the above results with those obtained from England and America.

From the geological point of view it is important to recognise that there are three methods by which base exchange between clay and a solution of sodium chloride can take place:—

(a) Deposits formed in water containing sodium salts in solution.

(b) Deposits formed in freshwater and subsequently submerged in sea water.

(c) Deposits formed in freshwater and afterwards submitted to base exchange with capillary solutions of sodium salts.

The base exchange to which the roofs of coal seams have been submitted is mainly of type (c). The conditions were similar to those now existing in the soil of the Nile delta. This is an important deduction in view of the discovery of peat containing fusain in this area.



Section of Medical and Veterinary Research.

*President:—*LT.-COL. R. E. WRIGHT, M.D., I.M.S.

Presidential Address.

OPHTHALMOLOGY IN RELATION TO RESEARCH.

LADIES AND GENTLEMEN,

As you are probably aware, I have been appointed at the eleventh hour to fill the place of Lt.-Col. R. Knowles, originally elected as President of the Section. I can only regret—with you—that he is not here to-day to do justice to the chair I occupy. This section heretofore has been almost confined to the consideration of research of one type or another and it is but fitting that a research worker should preside over it. It may, therefore, seem out of place that a clinician like myself should venture to address you although I had at one time the privilege of belonging to the Bacteriological Department, and have always tried to keep in touch with medical and veterinary research in this country. As my energies have been for a long time confined to work in the field of Ophthalmology, it will not surprise you if my address deals chiefly with this subject in its relation to research.

RESEARCH ORGANISATION IN INDIA.

Whether in the field of medical or veterinary science, the members of this section and our colleagues throughout the world are all potentially or actually research workers; and although the term research is now most frequently used in a somewhat special and limited sense, which does not even convey the same meaning to all of us, it should not necessarily be so restricted. When I first came to India organised research was almost confined to a small body of workers who devoted their energies to investigations in connection with bacteriology, immunology, entomology, protozoology, and parasitology. The nuclei round which these activities for the most part developed, were the centres for the investigation and prevention of smallpox, plague, rabies, snake bite, rinderpest and surra. Looking back now one might be inclined to consider that we brought very heavy weapons to bear on rabies and snake bite, which are comparatively unimportant economically; but the machinery was such, that the individuals employed found a suitable environment for launching forth into the investigation of the huge problems in connection with malaria, kala-azar, hookworm, cholera, water contamination, the dysenteries, the less understood fevers peculiar to

India, and the many contagious diseases of animals. Before this organised research started, there were, of course many distinguished scientific workers carrying out isolated investigations of the utmost importance. The same is true to-day, because it is impracticable, and undesirable, that there should be universal direction and control. It is important, however, that our researches should have international connections so as to secure the corrective of universal criticism. In the very early days some magnificent pieces of individual work stand out. It would be invidious to mention names, as many of those who figured so prominently in the world of tropical research are still amongst us. Sir Pardey Lukis made a great effort to co-ordinate medical research in India as a whole, and gradually an organised department was established. This, at first, was somewhat watertight, but by degrees a liaison was established between the public health services on the one hand and the clinical services on the other. The Bombay Bacteriological Laboratory at Parel, now known as the Haffkine Institute, played a large part in uniting the pure laboratory worker with the clinician, and the founding of the Calcutta School crowned the movement and established direct contact in a most suitable environment. Our provincial public health services are linked up with each other, and with the international health problems through the Public Health Commissioner, who keeps the Office Internationale d'Hygiene Publique, and the League of Nations Health Department in touch with India, and who also is closely identified with health activities in the Far East. We still look forward to the establishment of a powerful school of hygiene. It is said that such a school is destined for Calcutta, let us hope that the day is not far off when it will materialise and rival in vitality the School of Tropical Medicine. We may, however, congratulate ourselves that in the last twenty years the different types of work and the workers have been brought into more intimate contact. Now the individual investigator, whether engaged in the hospital clinic, in public health or veterinary field work, or in the laboratory, is able to establish co-operation with others who are willing to place their special facilities or knowledge at his disposal in order to enhance his endeavours.

The medical, veterinary and agricultural departments have come nearer, and some, at all events, realise the vast importance of a still more intimate association in connection with food problems,—both human and animal,—and the public health. But this is not sufficient. Investigations into the cause of disease in man and animals is so intimately related that it is hard to conceive of a medical worker being in a position to prosecute his researches with any great profundity without a good general knowledge of what has happened and is happening in the veterinary field, and *vice versa*. There are some medical men, and not a few of the laity, to whom veterinary work

appears to suggest little more than the treatment of sick cattle and dogs, or the granting of certificates for horses. A study of current veterinary literature would convince such persons of their lamentable ignorance. In bacteriological research particularly, the two sciences are so intimately bound up as to be inseparable. I have personally always enjoyed the fullest co-operation from my veterinary colleagues, and am indebted to them for much help and inspiration.

THE ULTIMATE OBJECT OF OUR RESEARCHES.

If then we regard the individuals of the Medical and Veterinary Departments as research workers in greater or lesser degree, what is the object of our combined efforts, what is the "big idea?" Ultimately, it is the advancement of the welfare of mankind. Darwin says, "Man, like every other animal, has no doubt advanced to his present high condition through a struggle for existence consequent on his rapid multiplication; and if he is to advance still higher, it is to be feared that he must remain subject to a severe struggle. Otherwise he would sink into indolence and the more gifted man would not be more successful in the battle of life than the less gifted. Hence our natural rate of increase though leading to many and obvious evils, must not be greatly diminished by any means." Again he says, "Important as the struggle for existence has been and even still is, yet as far as the highest part of man's nature is concerned there are other agencies more important. For the moral qualities are advanced, either directly or indirectly, much more through the efforts of habit, the reasoning powers, instruction, religion, etc., than through natural selection; though to this agency may be safely attributed the social instincts, which afforded the basis for the development of the moral sense."

"The high standard of our intellectual powers and moral disposition is the greatest difficulty which presents itself, after we have been driven to this conclusion on the origin of man." Since then Elliot Smith and others have shown us that man's intellectual supremacy is due to the expansion of the brain in connection with vision. "Smell was the foundation upon which the neopallium was begun and upon the distance-receptor vision it attained its highest perfection in man." (Parsons.) Elliot Smith says, "One could say with considerable confidence that the essential fact which brought about the emergence of man's distinctive qualities of mind depended, in the last resort, on the cultivation of the enhanced powers of conjugate movements of the eyes;" and again, "The acquisition of a macula was dependent on these powers of conjugate movement." Keith (1925) remarks, "One of the greatest services rendered to anatomy by Prof. Elliot Smith was the clear proof he gave,

fifteen years ago, that the evolution of bifoveate vision was the result of sight ousting smell as the dominant sense."... "It was clear that the superiority of man's vision lay, not in the kind of eye with which he had been provided, but in the brain which had grown up behind his eyes." This state of brain evolution,—which, phylogenetically under the influence of natural selection was determined by increased reliance on vision acquired by the lemurs, and, making its appearance at an early stage, (Eocene), determined the branching off of the true primates,—differs only in the higher and lower types of existing man, in those intellectual, social, and moral qualities above mentioned. These have appeared not in the course of natural selection, but in the modified or controlled state of social existence which man has adopted as the result of the acquisition of knowledge and reasoning. The elaboration of man's brain in his controlled evolution is to our research activities like the climbing of a mountain. As each higher level of intelligence is attained, so we are enabled to perceive and understand the activities at a lower level, which is impossible to those below. At every step the climber is only partially aware of what is happening in his own contour, if he would appreciate fully what is happening at this level he must get higher. So our intelligence strives in vague theorising after the view obtainable from the summit, not quite so blindly after the point just above us, which, after a time we make good, by the aid of a foot hold here, or a hand hold there, such as a new hypothesis in physics or discovery in chemistry. But the climber must have an appreciation of higher things, and aspire to reach them, not losing perspective and wandering aimlessly in his own contour, without recognising valuable aids, nor giving, nor receiving, help which would lead him upwards. During this period of controlled evolution, medical and veterinary sciences, (with the sciences on which they depend, and to which they are related), exercised a most important influence, but vision continued to play the prominent part in the evolution of man's brain. From the simple relief of human suffering and preservation of the individual life at one end of the horizon, to the higher flights of sociological endeavours,—into which our particular sciences imperceptibly merge,—and the national, and international machinery for the eventual improvement of man's lot, at the other, there is a caravan of individual and collective effort. It is impossible to foresee what the effect of all this control will be on the nation or on the race. Our veterinarians have been well aware for many years of the possibilities of improving stock by selection. This is not such a simple procedure as it might appear for many reasons, amongst others, the interference with fertility under more highly domesticated conditions of life. Man, however, in his own case, far from synchronising with natural laws such as those which determined

his appearance, has evolved those practices, arts and sciences, which, heal the cripple, foster the undesirable, make the conditions for the transmission of hereditary diseases more favourable, and handicap the progress of the more highly developed mental and physical types. All life is preserved,—good lives and bad,—and all agencies which are destructive to life are attacked ; in spite of the fact that under natural conditions multiplication tends to outrun the food supply, and that there is only room for a limited number. Are we fostering a deterioration ? Is it all a mistake ? How does one reconcile the preservation of *all* human life, the suppression of disease, the control of birth, and the elimination of war, with the ultimate production of the best human machines ? There are signs of disquietude, national and racial. We have periodic endeavours to eliminate undesirables. One European State has approved of the sterilisation of certain of the unfit, and the propagation of the mentally defective is limited, and may soon be controlled. America, awakened to the fact that her desirable racial types were being crowded out by the undesirables, introduced the quota. The position was even worse than that of Glasgow, where, apart from the undesirability of the actual invasion, the immigration of an Irishman, as Dr. Crew points out, may of itself prevent the birth of a Scotsman. It is admitted that the best racial types tend to commit race suicide. It may even be, that those who apply the details of medical veterinary and general research to the formulation of sociological laws, and otherwise tamper with the problem of population and genetics, may make such mistakes as to obliterate completely the highest products of man's evolution.

With such ideas in one's mind, it is somewhat comforting to turn to Sir G. Newman's reports for England and Wales, and realise, that during the last forty odd years, in a community moderately disciplined, and partially educated in matters of hygiene, the disease rate has diminished, the average duration of life has been prolonged, conditions of living have improved, the birth rate has fallen, and infant mortality has decreased, although the population during these years has outgrown the indigenous food supply. Instinctively we take it for granted, that, in the kaleidoscopic vista of controlled evolution, the part we are playing in the elimination of disease and suffering, and the betterment of the conditions of human life, must necessarily repercuss on the evolution of the brain, and eventually enable man to guide human destiny along an ascending plane.

THE GENERAL NATURE OF OUR ACTIVITIES.

As man's eventual welfare is ultimately dependent on the further development of his brain, this is the axis round which our activities in medical and veterinary science revolve. Let

us consider some of the ways in which the various members of the medical and veterinary professions employ themselves. For the most part they can be grouped according to whether their activities are mainly concerned with curative medicine and clinical investigation, laboratory investigation, or hygiene and public health, all of which are interdependent. We need hardly concern ourselves with the unborn child, but the expectant mother figures prominently in the public eye, and the toxæmias of pregnancy, and the high maternal mortality rate, are causes of the greatest concern to the obstetrician to-day. The new-born child comes immediately into the purview of some of the most elemental and far reaching investigations of modern medical and veterinary science, namely, those in connection with food stuffs and radiant energy. Here the medical and veterinary sciences go hand in hand and they must of necessity link up with the sister department of Agriculture. The economic importance of research in connection with nutrition, diet, and essential food factors in India is obvious, but it is only comparatively recently that it has developed a real scientific and practical side. McCarrison has done much to attract the agriculturists and veterinarians, and we hope for the greatest benefits from this line of research when co-operation is established between the various departments concerned.

As human beings develop and become liable to attack by the vast army of diseases, their conditions of life become the subject of attention from the three groups above mentioned, the clinician, who represents curative medicine, the exponent of hygiene and public health, representing preventive medicine, and the laboratory investigator, who, often too widely removed from his colleagues, pursues those more experimental and intensively detailed studies which are calculated to supply the key to the solution of the others difficulties. Curative medicine cannot be divorced from clinical research, and although there are some who hold that curative medicine is a luxury of civilisation, still, the human machine will need repairs as long as humane motives prompt the healing art, and the dictates of the instinct of self-preservation hold sway.

Systematised clinical medicine is the backbone of our professional activities. One has only to think of the great recent advances in plastic and brain surgery, or of that in connection with the air passages and transplantation, to realise the value of careful clinical investigation and to appreciate that surgery is not yet up against a dead end. But even now, just as when the new era of surgery dawned, its best efforts are based on the findings of the laboratory. It is to organised clinical investigation, in co-operation with the practitioner on the one hand, and the laboratory worker on the other, that we must look for rapid advances. Some of the highly organised clinics in America such as the Mayo Clinic, the Johns Hopkins

Hospital, and in Canada, the McGill University, have been steadily turning out systematic co-ordinated research work for years. The comparatively recent introduction of whole time clinicians and hospital units in the English schools, shows that a need of co-operation in education and clinical research was felt. Unorganised clinical research depends on the periodic appearance of giants in science. The recent investigation in connection with liver treatment in pernicious anaemia in the United Kingdom, shows how a number of different clinical centres all over the country can work in harmony with a directing head. In the investigations into chemotherapy, pharmacology and organotherapy we see some of the finest organised clinical work of recent years. The chemotherapist has practically flched one of the three great chronic granulomata from the surgeon, and launched a determined attack on the other two. On the other hand one of the greatest disgraces to our science is the way in which the inquiry into organotherapy has been allowed to drift into the hands of vendors who exploit the general public. These are encouraged by empiricists in the profession, who might do so much to help real research if a collective effort were organised. You are probably all inundated with pamphlets and circulars by mail from overseas, the bulk of which are got up to advertise organotherapeutic products. If the part of the contents which relates to Ophthalmology is an index of that which appertains to other branches of medical science, the responsible firms ought to be penalised. One would like to see a tax on such advertisements, as a protection to the public and the profession.

It is in the laboratory that the ultimate cause of disease is tracked down, and accurate means of diagnosis elaborated. Here the pure research worker finds his natural habitat. Up to now, in India, he has for the most part engaged himself with the ultimate problems which face the clinician and public health worker, and has been the base of supply, as it were, for these two in their attack on disease. But as there must be research in all branches of medical and veterinary science, the efficient laboratory system must have representation in all the roots of our sciences. Ideal research laboratories should therefore give a home to those subdivisions of research which deal with clinical medicine and surgery, nutrition, pharmacology, organotherapy, hygiene, and so on, in addition to those commonly associated with such institutions. The part played by our sciences in public health has made enormous strides of recent years. The work of the public health department, has, in association with the Indian Research Fund Association, made itself felt in international medical science. One can get a good general idea of the nature of our activities by contemplating the scope of the Proceedings of the Far Eastern Association of Tropical Medicine and Hygiene. As Col. Megaw has written, it "is now regarded

as the most valuable symposium of tropical medicine which has ever been held."

PERSPECTIVE AND CO-OPERATION.

The fact that curative medicine is readily marketable is often the undoing of members of the profession from the point of view of the individual pulling his weight in the combine. Provided however the clinician does not forget the first essentials of research, accurate observation, careful tabulation, and correct interpretation of facts and figures, he will always be the most important medical scientist to the man in the street, and essential to workers in the other branches. He may even at times be justified in feeling a little amused at the limitations of his brethren who are engaged in laboratory or public health work. The laboratory research worker who probes into isolated problems connected with the cause of disease, the man who, as he was described to me in the Rockefeller Institute last year, goes on finding out more and more about less and less, has perhaps some excuse for a limited horizon. His immediate effort is not so marketable as that of the clinician, and, it is considered that to take his attention off his work on account of such mere trifles as comparative affluence, is incompatible with research. The more rational view is that the research worker must not only be freed from the petty annoyance of making profit out of his work, but must also be put in such a position of well-being, as to allow of his care-free attention. In the best organisations to-day, this object is aimed at, but hardly yet achieved. It is probably true that if scientific research were properly organised and co-operation established,—not in medicine alone, but in the great basic sciences also,—it could wield a controlling power in the world's affairs. At present, science as a whole, is in the position of the medical laboratory research worker, exploited by those who pick its brains. We were reminded not long ago by His Excellency the Viceroy when speaking on Scientific Research, that according to one author, the true scientific method includes keeping no secrets, attempting no monopolies, serving no other end but knowledge. No doubt, to strive after the highest ideals in life's work is an attribute of the more advanced evolution of man's mind, but one sometimes wonders whether the politicians and the promoters of industry, who are so insistent on the ideal where the scientist is concerned, might not be encouraged to apply the same philosophy in their own spheres, if science had more organised power. One looks back on the ill-feeling in connection with Ehrlich's great researches in chemotherapy and his careful release of 606, and cannot help contrasting it very favourably with the uncontrolled way in which investigators of the properties of ductless glands place immature work in the hands of the big vendors of the refuse of the stock yards.

Diseases vary in what is considered to be their economic importance, and in this connection the Public Health worker comes in contact with employers of labour and the local authority concerned with the good of the people, with politicians, and with nations. Public health has largely become an international affair, and in this we see the nearest approach to the working of medical science for the "big idea." We are all a little inclined to think that our own particular line of action is vastly important, and by contrast, there is a lack of appreciation of the work of others going on around us. For instance an intense ophthalmological research worker in India might easily lose sight of the fact that many of his activities would cease if the Agricultural Department reached a high functional level, or the local authority followed the lead of the more advanced European countries in the control and treatment of venereal diseases. In any case, it might be for him an unpleasant contemplation as whole time employment on refraction work is a very dull occupation. Fortunately there are in the ranks of medicine not a few natural philosophers who from time to time remind us of what are really working towards in our continued, even if partially blind, effort, and stimulate us to readjust our perspective.

DIRECTION AND TRAINING.

The most important thing perhaps for the young research worker of to-day to remember, is that the mere gathering together of a few facts and presenting them afresh, or the growing or failure to grow some organism in a test tube, does not constitute research. Amongst the greatest research workers are those who are able to assemble and evaluate recorded facts. The man with the spade may spend hours of toil on a subject which is valueless to himself or anybody else. Direction in research is all important unless the worker is sufficiently trained to choose important lines along which to work. Above all, the modern research worker must have a training which was denied to many of the older members of the medical and veterinary professions, in the essentials,—the bedrock subjects,—physics and chemistry. Most other subjects fade into insignificance as compared with these, and naturally, they go hand in hand with mathematics. An appreciation of the literature is vastly important. The greatest mistake many workers make is, in not familiarising themselves with all the available work which was done before on the subject under consideration. Numbers of investigators waste months on a task which they might have avoided had they made a thorough preliminary survey of the literature. It is on deep foundations that the most important researches of the future must be built. The nature of the vital processes, the chemical, physical, and electrical activities of the

living cell, the interaction of the elements of vital tissues, the nature of energy and matter. These are the things of importance in the training of the younger generation. They must be able to use the more advanced teaching in those subjects as a means of interpreting and expressing their observations.

RESEARCH IN OPHTHALMOLOGY ILLUSTRATIVE OF, AND RELATED TO RESEARCH IN GENERAL.

We have seen that the advancement of the welfare of mankind is our goal, and that this is ultimately dependent on the further development of his brain. Further, we have seen that the brain of man reached its highest perfection through the agency of vision. It will not be inappropriate, therefore, if I give you an idea of some of the directions in which scientific investigation in connection with Ophthalmology has progressed of recent years. In doing so I shall endeavour to exemplify by reference to this localised, but vastly important field, many of those types of activities with which we are all concerned, and reflect in the mirror of Ophthalmological research, the various ways, in which medical and veterinary sciences in general, pursue the ultimate object of our endeavours.

The eye consists essentially of a globular outcrop of the brain which has become invaginated to form a cup, separated from the outside world by a transparent epithelium modified to form an optical system. The neural epithelium is capable of receiving distant stimulation by means of the radio-receptors,—the rods and cones,—so that it is possible for us to form an impression of a source of radiation at an enormous distance *e.g.*, a star. We can examine this receptive organ during life by accurate methods which we cannot apply to any other part of the body. The ophthalmoscope enables us to obtain a magnified view, (about fifteen diameters), of the finer vessels on the surface of the retina, which,—for all practical purposes is the surface of the brain,—so that we can observe over long periods the changes taking place in this important system of vessels, from their earliest stages right up to the establishment of gross disease. We are thus enabled to gauge more accurately, perhaps than by any other method applicable during life, the probable changes which take place in the cerebral vessels. It is not only possible to undertake this histopathological investigation of living tissues, but our observations may be recorded accurately and scientifically by means of photography. The photography of the fundus oculi has now reached a practical stage and this method will be increasingly used in the future to record serial observations of pathological processes. One of the greatest advances in this field has been made by the introduction of slit-lamp illumination in connection with the corneal microscope.

As Vögt has said, "with it Ophthalmology has entered on a new stage of development." The improved instruments enable us to throw a sharply cut narrow beam of light into the eye, so as to produce an optical section of the cornea and lens, which may be examined with the binocular microscope at practical magnifications up to fifty diameters; (magnifications of over a hundred diameters may be obtained, but are impracticable for various reasons). The study of the eye by this means is known as biomicroscopy or the histology of the living eye. We are enabled thereby to study not only such minute details of cellular structure as the corneal endothelium, but the optical heterogeneity of tissues such as the lens and vitreous is disclosed, and their "relucency,"—as it is called,—is revealed, so that they exhibit a structure which was not hitherto detectable in dead fixed tissues under the microscope. The help which the method has afforded in connection with the investigation of certain conditions, formerly of a doubtful nature, has rendered it indispensable. We owe our advances in this direction chiefly to the researches of Vögt, Köeppe, and Henker. It has been particularly useful in connection with the study of lenticular changes of a cataractous nature.

The subject of cataract has, as you know, occupied a very prominent place in ophthalmological literature, particularly in the field of surgery. The surgical treatment of cataract however, has probably had more than its share of prominence considering the relative economic importance of the subject, so I shall not do more than mention three of the factors, resulting from clinical research in technique, which have sprung into prominence of late. They are, the elaboration by Barraquer of the suction pump for removing the lens in its capsule, the adoption of some means of retaining the lips of the section in apposition after operation, and the more extended use of novocaine in obtaining a painless and motionless field of operation. These factors have been prominently before the minds of workers in many of the large clinics of the world, and as may be seen from the literature, Madras has not been behind hand. The method of blocking the main trunk of the seventh nerve near its exit from the skull, originally evolved here in the Government Ophthalmic Hospital, and now practised by us as a routine method, is coming into more general use. But research in this department of glorified carpentry is after all but temporising with the subject. As Duke-Elder, one of our ablest ophthalmological research workers of the younger school, has said, "When we as physicians fail to cure, and when we as surgeons lay down the test tube and take up the knife, we are, in so doing, merely confessing our failure as physicists chemists, and admitting that, as yet, our laboratory is too complicated for us to understand, our reagents too complex for us to manipulate, and our knowledge too fragmentary and inade-

quate for us to apply it systematically." It is pleasing at all events to know that many prominent investigators are alive to this fact in connection with cataract, and we are now in a position to demonstrate the production of cataractous changes in the eye of the rabbit in a few minutes by isolated infra-red rays, and to observe the process with the corneal microscope. The most important recent work, however, which has been done in cataract, is in connection with the chemical nature of lens protein. Lens protein is made up of several components, on the integrity of which its transparency depends. Under certain conditions a change takes place in one or more of these components rendering coagulation more liable to take place. There seems to be a strong school of thought, backed by an immense amount of experimental work in the realm of physico-chemistry, and radio-activity, which ascribes to the action of light on the constituents of lens protein, the first step,—the establishment of the predisposing factor as it were, in the production of cataract; other than complicated cataract. The equilibrium of the autoxidation system is interfered with and coagulative changes ensue. It is admitted on the other hand that typical instances of complicated cataract are due to alterations in the fluid available to the lens for its nutrition. The relative importance of these two processes appears to require much clarification. In so far as India is concerned, it is probable, that a very large number of cataracts labelled "senile," would more truly be styled complicated, and that alteration in the fluids which bathe the lens plays a leading role.

Most of you are no doubt familiar with Carrel's work on tissue culture. His original growths from heart muscle are still maintained in sub-culture. It is important for purposes of investigation in vitro to obtain a pure growth, and this is difficult, as it is desirable to use embryonic tissues. To remove the lens from a five day old chick embryo is not easy, but it is possible. Dr. Kirby, a New York ophthalmologist working under Carrel's direction, has elaborated this technique and thus obtained an absolutely pure mass of actively growing epiblast for culture. The epithelium, which grows well on a sterile plasma surface in embryo juice, does not resemble lens epithelium, it is for example opaque. This fact is of immediate importance to the investigator. One wonders whether it is possible to grow clear lens epithelium. It may be that this line of investigation, in conjunction with the chemical investigation of lens protein, will yield valuable results.

An entirely different type of investigation is that in connection with the filterable viruses. For many years bacteriologists have been faced with a certain type of acute infective disease which is not associated with a demonstrable cause. One helpful fact emerged in connection with the group, namely, that the virus was filterable in certain cases, and that it is probably

an ultra-microscopic living entity. In connection with certain of the so-called filter passers, observations have gradually crystallised into an hypothesis enunciated by Levaditi, that certain of them might be grouped as neurotropic ectodermoses. In this group some of the most informative work has been carried out on the herpetic affections of the eye. Here again we find the peculiar nature of the visual organ rendering material aid to a difficult research. The clinical processes in question are readily studied in the transparent cornea by the aid of the corneal microscope. You will, I trust, hear something of further interest on this subject when our research on the present extensive epidemic of superficial punctate keratitis is presented to the section.

Investigations in connection with Trachoma well illustrate how the cause of an important economic disease may ultimately be tracked down by a laboratory research worker. It had from ancient times given the clinician ample opportunity to demonstrate the futility of his curative methods, till, with the march of civilisation, it was taken out of his hands by the public health worker who dealt with it by segregation,—and that very effectively, as one may gather by the effect of the immigration laws put into force by the United States of America, and from a comparison between its spread in the Egyptian campaign early last century and its control in the late war. It may be too early yet to say definitely that Noguchi has discovered the causative organism of trachoma, and, even if he has, that it will afford a key to the control of the disease, but his work is a magnificent illustration of the adaptation of new methods of technique and procedure, in connection with the isolation of a causative organism. Bacteriologists had some time ago apparently arrived at an impasse; almost everything pathogenic to man that could be grown in a tube, with the limited media and methods available, had been grown. Noguchi, whose untimely death we have to deplore, was one of the pioneers in introducing new conceptions of cultural methods. Certain observers have failed to confirm his trachoma work, but it is doubtful if they have followed his technique. A few days before he sailed from New York for West Africa, Noguchi showed me his cultures of *B. granulosis* on semi-solid leptospira media, and demonstrated the disease produced by mass infection with pure cultures in his chimpanzees. His sections of the disease produced in monkeys were indistinguishable from sections of the human condition. His trachoma research has appeared as a supplement to the Journal of Experimental Medicine, and no doubt some of you have seen and admired this last fruit of his labours. Quite recently Prof. Axenfeld gave me to understand that Prof. Linder, who now holds the chair of Ophthalmology in Vienna and of those bacteriological investigations you have possibly heard, was on his

way to the Rockefeller Institute, New York; so the critical examination of Noguchi's work may be awaited in confidence.

The consideration of trachoma naturally leads one to think of the other great economic affections of the eyes. The commonest cause of blindness in England and Wales, according to the Departmental Committee on the Causes and Prevention of blindness, is ophthalmia neonatorum. Not only is gonorrhoea of enormous importance, but so also is syphilis, competing with congenital defects for second place as a cause of blindness in infancy, accounting for a high percentage of the blindness of adults also. Venereal disease in various forms when looked at from the point of view of interference with human vision, on which our welfare so largely depends, assumes enormous relative importance. In certain countries maternity training and propaganda in connection with the prophylaxis of ophthalmia neonatorum has brought the attack rate to an apparently irreducible minimum which is still deplorably high. In England the Council of British Ophthalmologists, which exercises such an important influence on all matters touching the sight of the nation, has taken the further improvement of preventive measures in hand. The control of syphilis is progressing rapidly. The whole nature of the disease is ameliorating, and in this we have an example of a condition in which organised curative medicine in the mass, when founded on sure chemotherapy, may prove a better weapon than preventive medicine.

In India it is more difficult to evaluate the chief causes of preventible blindness. In the first place it is not possible to get accurate figures for the serious affections which attack the eye in the first month, year, or age period. Here we have an example of the importance of maintaining adequate returns for the compilation and application of vital statistics. It has been assumed that ophthalmia neonatorum is as important a cause of preventible blindness in India as in England. There are, however, some facts bearing on this assumption which must be considered. Ophthalmia neonatorum appears to be milder affection in India,—at least amongst the inhabitants of Madras,—than it is in Europe; syphilis of the eye in the first year is not uncommon, and this, together with smallpox, kerato-malacia, and the application of irritant remedies, account for a relatively large amount of damage to the eyes in the first few years. It is probable that preventible blindness has been vastly reduced in this Presidency by better methods of vaccine production established by Cunningham, resulting in a higher protection rate, but reliable statistics are again necessary to confirm this view. This consideration helps us to appreciate in proper perspective the value of the laboratory worker, and the field worker, to an apparently isolated clinical section of the medical department. It might be a disquieting thought, that the King Institute of Preventive Medicine, Guindy, has perhaps done as

much (or more) towards the prevention of blindness as the Government Ophthalmic Hospital, if we did not appreciate the work done by others and the fact that prevention is a more potent factor in the elimination of disease than cure.

Keratomalacia is a condition, the economic importance of which may have been heretofore underestimated, as it is not very uncommon in the early age periods and may mount up by summation of effects to a very important cause of the blindness at all ages in South India. As you know keratomalacia is a familiar affection in ophthalmic hospitals in India,—perhaps most so in Madras. At the last Congress here, some of our work at the Government Ophthalmic Hospital on this subject was brought forward. Since that time enormous strides have been made in the realm of deficiency diseases, but we are very far from reducing them to concrete terms of physics and chemistry. In so far as clinical ophthalmology is concerned, we are in the same position now as five years ago. Cod liver oil is the best all round method of treating keratomalacia. It is marvellous to watch an appalling condition of the eyes (and, of course, the respiratory and alimentary tract in the advanced condition), clear up under this treatment, and this alone.

The importance of combating the six affections due to small-pox, gonorrhoea, syphilis, irritant remedies, trachoma and keratomalacia, on account of their attack on the eyes in early life, is not realised in this country. Intensive propaganda work is urgently required. Money spent in this connection would be better spent than in establishing institutions for the blind, which although humane in intention, is beginning at the wrong end. The support of propaganda efforts has, up to now, been unenthusiastic.

Besides keratomalacia, there are other eye affections which are dependent on the proper relations of essential food factors and the endocrine glands. We know that sun light is the activating factor in the production of food stuffs which are essential in maintaining normality. Both the cow and the grass must be irradiated if the milk is to have its full value. Indirectly we may have the eyes affected via this route, for example, in some of the juvenile cataracts. Von Szily, too, has demonstrated the production of cataract in suckling rats by withholding Vitamin A from the mother, the so-called avitamine cataract.

The foregoing considerations lead us naturally to the subject of radiation in Ophthalmology. The nature of light is at present in such a state of flux, and constitutes such a complicated problem, that we cannot here consider with advantage its full bearing on our investigations. We presume that life ultimately depends on light. Radiant energy to which the eye is transparent is harmless. It is rays which are absorbed which may damage the eye. These are notably the rays which

merge with either end of the visible spectrum, the infra-red at the long end and the ultra-violet at the other. The radiant energy of wave lengths in between, *i.e.*, white light,—which may be split up into its component parts as the visible spectrum,—is for the most part absorbed with the production of visual sensation. If in excess, part of it may be degraded into heat. The absorption of infra-red, in greater amount than can be counteracted by the nature of the tissues, gives rise to a thermal lesion. We have seen above that such lesions may be demonstrated experimentally, *e.g.*, cataractous changes in the lens. A concentration of infra-red rays at the macula, such as occurs, for example, during the ritual of sun gazing, or observing an eclipse of the sun without adequate protection, may produce an actual thermal lesion at the macula. The rays of short wave length,—the ultra-violet,—produce abiotic lesions, chiefly of the superficial parts. We do not yet know how far the investigations into the noxious influences associated with the absorption of heat waves and ultra-violet radiation may lead us. In India we are not very much concerned with the abiotic phenomena produced in the eye by ultra-violet radiation, although they are familiar enough at high altitudes. In the plains, however, it may be that the effects of the absorption of the infra-red radiations are of more far-reaching importance than we have any conception of. Duke-Elder has prosecuted the most interesting enquiry into the therapeutic action of ultra-violet light on certain diseases of the eye. The general action of controlled ultra-violet radiation appears to be associated with a raising of the bactericidal power of the blood. The eye diseases which respond best to general treatment appear to be tuberculosis and scrofulous conjunctivitis. For diseases of the cornea he uses a special mercury vapour lamp from which a beam may be thrown on the cornea in such a way as not to impinge on the lens. Various forms of blepharitis, conjunctivitis, and keratitis have been treated with good results. The value of irradiated ergosterol has not yet been established as of value.

One often hears it said that refraction is the “bread and butter” of Ophthalmology. This may be so to limited extent, although the examination of the eyes in connection with optical defects, if done properly, is a time-absorbing process. As in many other varieties of medical relief, it is not always done properly. This is very largely determined by the attitude of the general public, and to a less extent by the Ophthalmologist. It is not yet generally realised that the eventual well-being of the eyes is very largely bound up with this problem of accurate correction with spectacles, although Edward Jackson,—the doyen of American Ophthalmology,—does not leave one in doubt on this point. Given eyes that have some visual acuity, it is essential to obtain the best optical results by means of artificial aids,—for

by not doing so, latent disease may be fostered or a liability established. It is significant that,—as noted here by my predecessor Col. Kirkpatrick while observing cataract cases,—it is often in the eye with the greater error of refraction that a cataractous process first starts. The amount of work done on refraction in the last twenty years is enormous, although not more so than is commensurate with its importance, but except in the special literature, it does not attract much attention. It is a difficult study involving basic principles, and research in this connection is not so “flashy” as in the less important operative fields, but fortunately there are those who realise the full value of correcting errors of refraction and muscle balance. In the English-speaking world, we owe a great deal in this respect to Duane and Jackson in America, Maddox and Percival in England, but the disabilities and loss of efficiency due to uncorrected errors of refraction are still not appreciated, even by the members of the profession.

The anatomy of the eye has attracted very considerable attention in recent years. Prof. Arthur Thompson of Oxford has been prominently identified with this movement. His association with Ophthalmology was linked with that of Doynne, a most distinguished investigator of clinical Ophthalmology, who founded the Oxford Ophthalmological Congress. Prof. Thompson is responsible for the beautiful anatomical production, “The Anatomy of the Human eye as illustrated by enlarged Stereoscopic Photographs,” and Prof. Whitnall, formerly his Demonstrator, now Professor at McGill University, published a few years ago “The Anatomy of the Human Orbit and Accessory Organs of Vision.” Some of you are possibly familiar with Onodi’s work on the nasal accessory sinuses, and may perhaps have seen those of his dissections acquired for the Museum of the Royal College of Surgeons. Onodi’s work on “The Optic Nerve and Accessory Sinuses of the Nose,” was an important addition to our knowledge of the relation between diseases of the nose and of the eye, and, as an applied anatomical study, gave a clear idea of the relations of the nasal accessory sinuses to the orbit. The region of the basi-sphenoid is of the utmost importance to the eye specialist, because the optic nerves are intimately related to the great air cells and to the pituitary fossa, and subject to damage by pathological conditions of either. In connection with this part of the body investigations by means of radiography have advanced enormously of recent years. The highest standard of radiographic work is essential in making diagnoses in this region, as for instance the demonstration of expansion of the optic foramina. You are probably all aware that in Madras we have the advantage of an excellent service in this respect.

Embryology is a subject which does not at first appear to offer a very fruitful field for ophthalmological research. Yet

one has only to read Miss Mann's recent classical contribution to the literature to realise that her observations have thrown considerable light on some clinical problems *e.g.*, congenital defects. In addition she gives a clear conception of the ultimate nature of the structure of the eye, on which to found rational ideas of pathological processes.

A great deal of work had been published by continental writers, but Miss Mann, as the result of her investigations on a unique series of human embryos, produced the first comprehensive account of the subject in the English language.

The research which has perhaps caused the greatest stir in ophthalmological circles is that of Duke-Elder on "The nature of the intraocular fluids" as related to glaucoma. With a more elaborate and delicate technique that has hitherto been considered practicable, he has measured the actual pressure in the retinal arteries and veins, and arrived at an idea as to the pressure variations in the capillaries. The hypothesis is put forward that the aqueous is a dialysate in equilibrium with the capillary blood, that there is no real circulation of the aqueous as previously understood, and that its escape by means of the filtration angle only takes place as an adjusting mechanism when the intra-ocular pressure rises above that in the canal of Schlemm. The vascular bed normally maintains a pressure at which an adequate circulation is maintained and thermo-dynamic equilibrium is established between the aqueous and the capillary plasma. Variations from this level may occur through, (a) altering the equilibrium level, either by a change in blood pressure in the capillaries, a change in osmotic pressure between the aqueous and capillary plasma: or, (b) varying the volume pressure inside the eye, by alteration in dilation of the uveal vessels, varying the quantity of aqueous, or varying the volume of the vitreous or lens. Duke-Elder's work has enabled us to rearrange our ideas of glaucoma, and helped those whose working knowledge of chemistry and physics was insufficient adequately to express the phenomena which they had observed, to form a clearer conception of the nature of this important affection. So far, however, the effect of these researches on treatment has not made itself felt except in one direction,—namely, that of rapidly reducing the intra-ocular tension by means of intravenous injections of hypertonic saline, so that we are still in the position of having to treat our cases by operation. As most of you are aware it is the operation which Elliot established here in Madras which is used by the majority of surgeons the world over to-day. It is not merely the operation of sclero-corneal trephining, however, but the careful clinical investigations which led up to its adoption, and studies in Ophthalmology, especially those in tropical Ophthalmology, which have established the reputation of my distinguished predecessor, and linked up the name of Madras with scientific Ophthalmology

wherever it is practised. The operative treatment of glaucoma is, however, but a temporary phase and a confession of ignorance. Work is gradually accumulating which may at no very remote date bring this appalling disease within the control of the physician. The main subject chosen for discussion at the International Congress of Ophthalmology this year is the non-operative treatment of glaucoma. Here in Madras we have a vast amount of material at hand, but in trying to utilise it we are driven back on that last line of defence—behind which many of our problems take refuge,—the obscurity of the physical and chemical processes involved. Some progress has been made both by the compilation of clinical observations and empirical treatment, and by more exact methods undertaken for us by the Professors of Chemistry and Biochemistry. One fact appears to stand out in connection with certain varieties of glaucoma,—as indeed with certain varieties of cataract,—and that is the association which exists between these diseases and involutionary change. This picture of involutionary change is constantly before the ophthalmologist in India, at least in the south. It is at present impossible to picture its essential pathological processes. It is suggestive that they resemble for example those of chronic anaphylaxis and that the alimentary tract is frequently abnormal. It is obvious that there are numerous milestones on the road which leads from the newly born apparently healthy child to the grey haired, atrophic skinned, cataractous involute, of thirty to forty. Many of them are obscure, but at least some are visible, namely, the consequences of excessive thermal radiation and inadequate food supply near the one end, and a damaged capillary endothelium near the other. There is invariably a summation of chemical and physical insults to the cells of the body as life goes on which finds expression in atrophy, degeneration, and death. In South India the lack of energy supplies,—both enteral and extra-ental,—together with the direct and indirect evils of infra-red radiation, are factors which operate conspicuously.

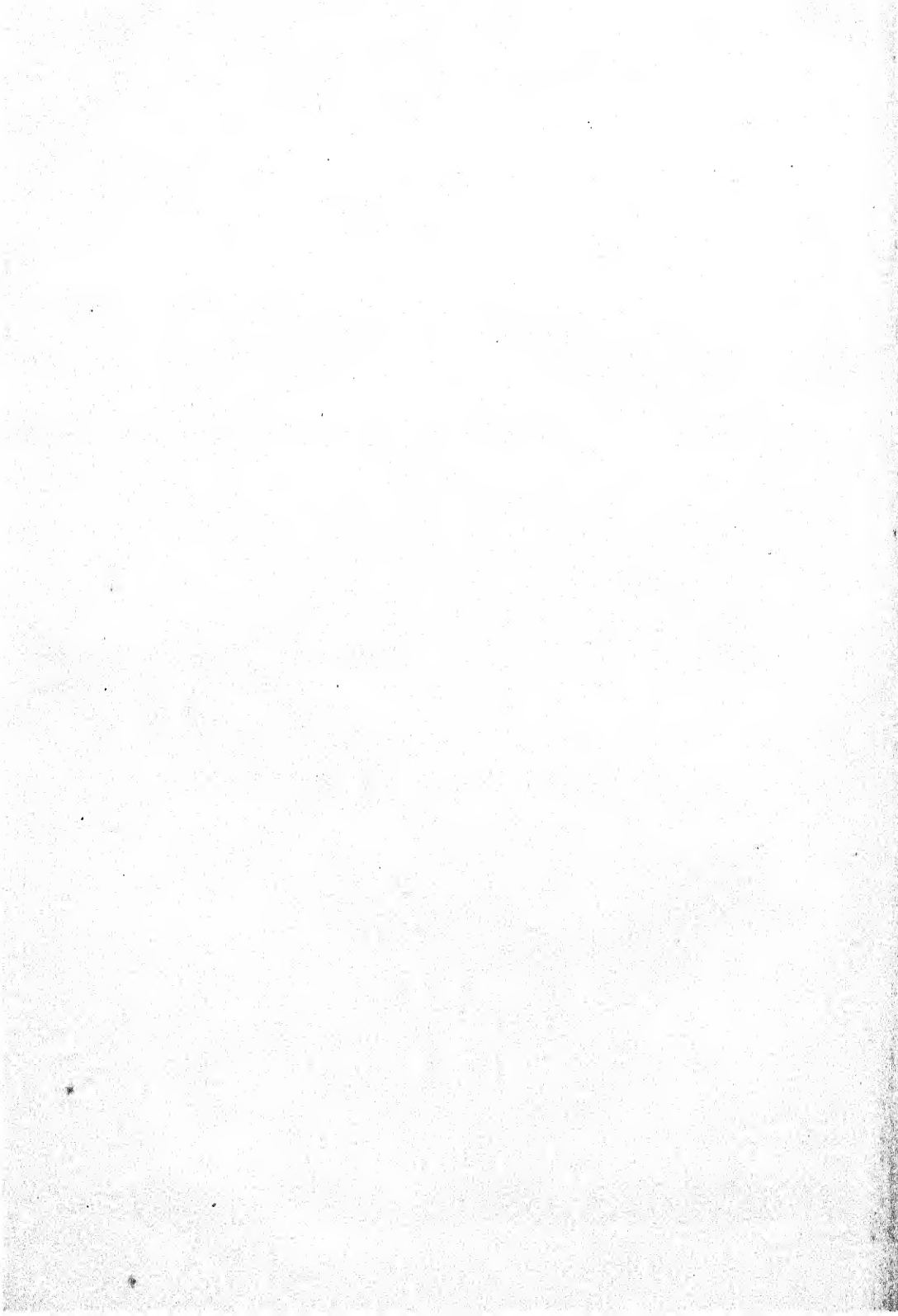
In the field of physiological research, vision has naturally always claimed a large share. One of the most profound and important directions in which much progress has been made of recent years is the relation between the eyes and the labyrinth, and the functions of the eye in connection with the postural reflexes. The decerebrate animal orientates itself in response to forces acting on it, such as gravity, by a reflex mechanism which depends for the most part on the labyrinth whereby a movement of the head except horizontally, is compensated for by a movement of the eyes. In the neck reflexes, the movements of the head in *any* direction are accompanied by compensating eye movements. If the cerebral hemispheres are removed, a resting animal orientates itself, and recovers its ordinary posture when

aroused, by righting reflexes, acting through the mid-brain and labyrinth. In the monkey, provided the visual cortex remains, the righting reflexes are preserved even after labyrinthectomy. So that in higher animals the eyes can compensate for the loss of the labyrinths, the dominating influence of binocular vision coming into play.

As a final instance of research in connection with the eyes, we may consider the philosophical investigation of that most eminent ophthalmologist, Sir John Herbert Parsons. In his recent work, "An introduction to the Theory of perception," we have a magnificent example of synthetic reasoning built up around the phenomena of vision. He hypothecates a biological basis for the phenomena of the higher visual and other perceptual processes, and advocates the development of psychology on a sound biological basis. He traces the genesis of perception from the lower levels phylogenetically where undifferentiated receipts give rise to responses vital to the preservation of the species. With further differentiation certain functions of the nervous mechanism assume a preponderant role *e.g.*, the olfactory apparatus in certain lower animals. The primates have attained their supremacy through the predominance of their visual function. From the human point of view perception appears to be the result of the correlation and integration of many and diverse sensory factors. Head propounded a dual mechanism for cutaneous sensation; a primitive protopathic and a more differentiated epicritic. Rivers applied the same idea to more complex integrations, instincts being essentially protopathic, whilst intelligent control of lower functions is epicritic. Parsons elaborates and modifies this line of reasoning. He hypothecates a dyscritic mechanism on which an epicritic is superimposed, and at a higher level still, "a syncritic mechanism, subserved by the cortex cerebri, having the function of integrating epicritic phenomena." He says "Since perception is a phenomenon of consciousness, every inference must be derived from human experience: and since vision is the preponderant modality in the primates and has undergone the highest differentiation, it may be expected to afford especially valuable data. For that reason, and because it has been my own special study for many years, most of this thesis is devoted to that aspect of the subject.....for I am convinced that psychology, as a science can only be developed on a sound biological basis." Consciousness has developed in evolution because of its utility to the animal in sorting out, arranging, and utilising the messages which come in from the various receiving stations. To continue the simile, the man in the street cannot form a mental picture of what goes on in the head office with regard to decoding, retransmission, etc., but he may reasonably presume that it is similar in mechanism to what takes place at the receiving stations,

with which he is familiar. If he wants to appreciate fully what is happening in the various internal departments, he must not only have had experience in them, but have had the further experience of directing them. To be more technical, it is only by "back stroke" from a higher level of cortical experience that we are able to appreciate fully the nature of phenomena at lower levels. Sir John Parson's treatment of this subject illustrates, in so far as our research activities are concerned, integration at a syncritic level,—to use his own word,—and makes his reader feel the urgent need of accumulating experience of the basic facts of physics and chemistry, so as to utilise them by means of this mechanism in the elucidation of those phenomena which are incomprehensible without their aid.

And now having led you in thought to some of those higher pinnacles of our endeavours, let me conclude this discourse with an anticlimax. In so far as India is concerned, so long as the mind of the masses remains at such a low level of education in hygiene as it is to-day, we are only knocking our heads against a mud wall in trying to impose western curative and preventive medicine on a large scale. So long as the food supply remains limited, under present hygienic conditions, the population density will be adjusted to its food supply by catastrophic natural means, such as pestilence or famine, rather than by the more orderly proceeding of a fall in the birth rate. India is a magnificent field for medical and veterinary research, and all honest work done in this respect goes to pile up the credit balance placed at man's disposal for own ultimate good, but the results are for the most part inassimilable by the masses in India for want of education in hygiene.



Section of Medical and Veterinary Research.

Abstracts.

1. Persistent thymus.

T. B. MENON, Madras.

The association of a persistent thymus with medico-legal deaths is brought forward. The argument is advanced that this persistence is not in any way related to the cause of death but with the rapidity of it. A persistent thymus has been found in sudden deaths whether the cause of death is from gun shot wounds, motor accidents, railway accidents or post-operative shock. The condition of the thymus is regarded in these cases as that of the unaltered thymus taking into account Hammar's view of the normal persistence of the thymus in adults. The view is advanced that the thymus is an organ which is the first to undergo atrophic changes in protracted forms of death and this accounts for the condition of the organ in the adults in ordinary hospital autopsies.

2. The treatment of peptic ulcers.

K. G. PANDALAI, Madras.

The treatment of gastric and duodenal ulcers, which are common diseases in this presidency, is still in a stage of evolution. Efficient treatment with medicines alone is prolonged and in its results palliative, and is possible only to the better classes who could spare the necessary time and money. To the average man who wants to return to work as quickly as possible, surgical treatment is the only resource and hitherto the operation of gastro-enterostomy which has become the standard operation for this disease has failed to give relief in a percentage of cases, variously estimated. As it is impossible to predict which case will benefit by gastro-enterostomy and which will not, it is suggested that the more radical operation of partial gastrectomy be more widely utilised. The comparative results of the two methods based on the figures of the Second Surgeon, General Hospital, Madras, are tabulated.

3. The relationship of the red cell sedimentation rate to various clinical conditions in pulmonary tuberculosis.

M. KESAVA PAI, K. VENKAT RAO, C. A. VENUGOPAL and
P. K. GUNASAGARAM.

Since the original researches of Fahraeus and Westergren a considerable amount of work has been done on the blood sedimentation reaction especially in pulmonary tuberculosis. The details of the technique of the test especially as regards the air temperature, length of blood column, time elapsing between the extraction of blood and the sedimentation test are very important in comparing results obtained by different workers. Using Westergren's method the writers have found that under the tropical conditions of Madras the rate of sedimentation is much higher than in Europe and in the hill climate of Arogyavaram in South India both in normal and tuberculous subjects. The rate of sedimentation increases with the stage of the disease and the toxicity of the attack. Bacillus positive cases give higher sedimentation than bacillus negative cases and highly febrile cases more than sub-febrile and afebrile. There is no

relationship between the sedimentation reaction and the complement fixation reaction. The sedimentation rate is a good index of the prognosis and lessens when the patient improves and gains weight, increasing under opposite conditions. The decrease of sedimentation rate is practically the same whether the improvement be due to general treatment, artificial pneumothorax or chemo-therapy, but the more rapid the improvement the faster the decrease of the sedimentation rate. There is a direct relation between the sedimentation curve and the prognosis of cases of pulmonary tuberculosis and the periodic application of the test is as valuable as the record of the temperature and general clinical progress, often giving timely warning of exacerbations, before any other clinical signs.

4. The prognostic value of the cutaneous tuberculin test and the tubercle complement fixation reaction in pulmonary tuberculosis.

M. KESAVA PAI, K. VENKAT RAO and C. A. VENUGOPAL.

Though a weakening of Von Pirquet's skin reaction is known to occur in the terminal stages of tuberculosis especially when acute complications set in, the reactivity of the skin to tuberculin remains mostly unaffected in the progress of cases of pulmonary tuberculosis observed for long periods. Massias, Armand Delille and others think that the T.C.F.R. gives no indication of the stage of the disease or of the prognosis, whilst Thiodet considers that the T.C.F.R. increases with favourable progress and decreases with progression of the disease. Our experience in 106 cases of pulmonary tuberculosis observed over long periods shows that neither the T.C.F.R. nor the V.P.R. gives any indication of the prognosis, as they remain unchanged in the majority of cases either progressing or retrogressing.

5. On a comparative study of the effect of climate and of the seasons on body weight in pulmonary tuberculosis in different countries.

M. KESAVA PAI, Madras.

There is a constant and definite relationship between the atmospheric temperature and humidity and the seasons of the year on the one hand and the fluctuations in body weight of tuberculous patients on the other. A hot and dry season retards increase of weight and moist and cool weather promotes the increase of body weight. Extremes of heat and cold are detrimental to assimilation and increase of body weight whilst a cool and pleasant temperature with optimum humidity tends to increase body weight in tuberculosis. From this it can be understood why in temperate climates like that of Europe, there is a marked increase of body weight in spring, late summer and autumn with their cool and humid atmospheric conditions and a retardation of such increase in winter and midsummer with their extremes of temperature affecting metabolism and assimilation unfavourably. In the tropics there is a definite and marked tendency for increase of weight during the cool season and the cooler, humid and rainy months and a retardation during the hotter and drier months. This explains why in Madras and other places in South India there is a much greater increase of body weight amongst tuberculous patients in the months November to February and a much lesser increase during March to October, there being a slight rise in the weight curve during June to October in areas cooled by the moist south-west winds, as in Arogyavaram.

6. On the efficacy of sanocrysin treatment in the different types of pulmonary tuberculosis with an analysis of 84 cases.

M. KESAVA PAI, Madras.

The rational application of gold therapy in pulmonary tuberculosis is of comparatively recent origin. Moellgaard considers sanocrysin acts biochemically, whilst others think it acts chemically. The Danish workers advocate large doses whilst most others advise smaller doses. It was originally considered that exudative cases are benefited much more than proliferative cases, but later workers, especially in India, have shown that it is equally beneficial in fibro-caseous pulmonary tuberculosis. Tubercle bacilli disappear in 30 to 40 % cases by sanocrysin therapy and the less toxic cases are influenced more effectively than the more toxic. Body weight decreases at first, but later increases during the treatment. Sanocrysin shock, albuminuria, enteritis, etc., can be more or less avoided by cautious dosage.

7. The comparative value of Ehrlich's Diazo reaction and Weisz's urochromogen test with special reference to pulmonary tuberculosis.

M. KESAVA PAI, C. A. VENUGOPAL and P. K. GUNASAGARAM.

The urochromogen in Weisz's reaction is considered to be a precursor of the urochrome of the Diazo reactions as judged by laboratory and clinical observations. A large number of workers consider that the Weisz reaction is detected earlier in the course of tuberculosis and is present in a larger number of cases than the Diazo reaction. Whilst the majority of clinicians consider that a strong Weisz or Diazo reaction indicates a grave prognosis a few think that a strong reaction does not necessarily mean the prospects are bad. When a positive reaction becomes negative the case is usually observed to be convalescing and vice versa. The writers conducted over 700 tests with 300 cases and found that though the Weisz reaction gives a larger percentage of positive results in the earlier stages of pulmonary tuberculosis it gives fewer positives than the Diazo test in the later stages. The test gives 8 % to 9 % positive results in clinically non-tuberculous cases. Bacillus positive cases of pulmonary tuberculosis give a higher percentage of Diazo and Weisz reactions than bacillus negative cases and patients in more advanced stages than those in the earlier stages. More toxic cases as denoted by the daily temperature range, give a larger number of positive reactions than less toxic cases. The two tests can be used for deciding the prognosis by a graphic measurement of the degree of reactions time after time but the writers could not in this preliminary work agree with others that the Weisz test gives more reliable results than the Diazo.

8. On the reservoir of epidemic cholera.

LT.-COL. DUNN and S. KHAN.

It is of great importance to know the reservoir of cholera for if it can be blotted out cholera would become an extinct disease. An enquiry into the causes responsible for the origin of cholera in the United Provinces was instituted by the Indian Research Fund Association. Mention is made of certain observations regarding the reservoir of epidemic cholera that were made in the course of this enquiry.

It has been shown that chronic carriers of cholera do not exist. The so called non-agglutinating vibrios are also not the reservoir of the disease. No evidence was discovered to show that they can give rise to epidemic cholera.

The conclusion arrived at is that the reservoir of cholera are the actual cases in the active stage of the disease, in the incubation period of a week or so, or in the convalescing period of 15-30 days.

The spread of cholera depends on the presence of actual cases of cholera all the year round somewhere in India. It is immaterial where this place is, provided free communication takes place with it through human beings. Any concourse of people of such a nature and magnitude as to ensure the presence of such cases is liable to an outbreak of cholera especially when the temperature is suitable.

9. Infantile biliary cirrhosis.

S. P. BHATTACHARYA, Calcutta.

Introduction.—This is an intercellular cirrhosis seen in children of better and middle class people in Bengal. The cirrhosis is different to that described by Hanot's and probably inherited and is more acute.

Distribution in India.—So far as known.

Epidemiological factors.—Will be discussed in detail and the main factors, social problem, etc. will be described.

Symptomatology and Laboratory findings will be given; all the tests by Liver puncture, etc. are negative. The test show hyperglycaemia in advanced cases only.

Marked sugar tolerance and defective function of the liver cells noticed.

Pathological changes.—Postmortem and histological findings. Cause of death. *Treatment.*

10. The incidence of primary carcinoma of liver in South India.

P. N. BASU and A. VASUDEVAN, Madras.

Contrary to the general observation elsewhere, our statistics of carcinoma of liver in South India, show a great proportion of primary carcinoma of liver as compared to the secondary ones. The ratio of the primary tumours to the secondary ones is 1.45 : 1. Age, sex and caste incidence is given. Two types of carcinoma of liver are found and these are (a) Primary "liver cell" type of carcinoma or the malignant hepatoma starting from the liver cells and (b) Primary bile duct carcinoma (columnar cell carcinoma) starting from intra hepatic bile ducts. The former is the commoner of the two. Both are associated with cirrhosis of liver—the multilobular variety which is a common condition in South India. Descriptive pathological notes of two cases typical of each variety are given, with photographs and micro-photographs.

11. Animal experiments with *B. Welchii* isolated from fæces of cases of anæmia of pregnancy.

MANECK M. MEHTA.

Whole living cultures of *B. welchii* inoculated subcutaneously or intraperitoneally in guinea-pigs in repeated doses produced slight anæmia and even death. Supernatant liquid obtained by centrifuging *B. welchii* broth culture did not produce an immediate effect, but when inoculated in repeated doses, a fairly well marked anæmia was produced resembling the pernicious type in man and in some cases death supervened without anæmia. This anæmia was characterised by remissions when the injections were discontinued.

Toxins, prepared by passing *B. welchii* broth culture through Chamberland filters when given subcutaneously or intraperitoneally produced no anæmia.

B. welchii culture and toxins were pathogenic to the unborn young. The young were invariably still-born or died within a fortnight after birth.

Feeding with repeated doses of living culture of *B. welchii* even when each dose was preceded by Sodium fluoride failed to produce anaemia. If at the same time the animals were kept without greens in diet death without signs of anaemia supervened.

Treatment of pregnant animals with Sodium fluoride alone or followed by *B. welchii* culture was toxic to the unborn young which were nearly always still-born or died shortly after birth.

12. The relative toxicity and immunising value of Haffkine's Plague Prophylactic compared with other anti-plague vaccines.

B. P. B. NAIDU and JAMEDAR SHAMSHER JUNG, Bombay.

Experiments carried out in rats, guinea-pigs and rabbits showed that rats were the animals of choice for estimating the toxicity and potency of anti-plague vaccines. The relative toxicity and immunising value of the different anti-plague vaccines now in use have been studied in rats. The results go to show that agar-grown vaccines even in a dose of one cc. (dose for man) have low immunising value compared with that of Haffkine's Prophylactic in a dose of 0.5 cc. (one-eighth the human dose) and that agar-grown vaccines are not less toxic for rats than the Prophylactic.

13. Attempts at the production of a potent anti-plague serum.

B. P. B. NAIDU and JAMEDAR SHAMSHER JUNG, Bombay.

Results following the therapeutic use of anti-plague sera have hitherto been satisfactory. Attempts are being made to prepare anti-plague sera from animals other than horses. While immune sera of horses produce little or no agglutination with cultures of plague, the immune sera from rabbits, sheep and calves vary in their agglutinating titre. Experimental results show that with highly agglutinating sera of rabbits better therapeutic results are obtained in experimentally infected rabbits than with sera of little or no agglutinating property.

14. Food value of the nut known as Hijli Badam.

N. K. CHATTERJEE, Calcutta.

Hijli badam, cashew, nut of Hijli, Bengal, generally called Kaju in east and west coast of India was introduced in 17th century from South America and were established in the sandy tract of Hijli, Chittagong in Bengal, and other places in India. Its kernel is extensively eaten by local people as supplementary staple food.

Identification:—This species cannot be confounded with other. This plant belongs to the genus *Anacardium*, species *A. occidentale*, natural order *Anacardiaceae* (Linne). Tree is 30 to 40 ft. high having nut kidney shaped seated upon a large pyriform fleshy body mistakingly called its fruit.

Limits of cultivation:—Its growth does not produce any untoward local condition to consider the limit of its cultivation; on the other hand its growth is limited only in rather barren coastal sandy tracts.

Economic value. Sufficient quantity of nut is produced from a tree. There is an extensive trade at Bombay of the exported nut from Goa, the price of 1 Cwt. is about Rs. 18. Durable wood is available from the trunk. Bark is used for tanning and dyeing. Reddish brown oil from

pericarp has some medicinal value and is used in paint. Spirit is obtained from the fleshy torus called fruit.

Food value:—The nut is eaten raw and roasted. All the proximate principles of food are found in it—the prominent one is fat. In comparison with milk it is more rich and nutritious.

Oil is the chief product. It is almost equal to almond oil. It is yellow bland oil resembling groundnut and mahua oils, so far as chemical figures are concerned.

Influence on the nutrition has been investigated by feeding young rats with kernel of the nut. Satisfactory results are being obtained.

Conclusion:—Its cultivation is to be advocated on the ground of its usefulness as an article of food, specially the oil which is an edible vegetable fat.

15. Observations on the medico-legal application of blood-grouping with a note on blood groups in a polyandrous family.

M. N. LAHIRI.

A short description is given of the two rival hypotheses explaining the Mendelian inheritance of hæmagglutinins and hæmagglutinogens in the human.

An interesting example of polyandry of the paternal type is described the existence of which was brought to light by blood-grouping tests.

16. The distribution of the blood-groups in certain races and castes of India.

R. H. MALONE and M. N. LAHIRI.

This paper gives the results of the examination of the bloods of 1,407 persons classified into three races or types, the Turko-Iranian represented by people of the north-west frontier, the Indo-Aryan represented by Rajputs, Jats and Khetris of the Punjab and the Dravidian represented by Santals, Mundas, and Oraons of the Chota-Nagpur District.

The authors show that there is a relation between the frequencies of the four blood groups and the anthropological characters of the three races the Dravidian possessing the highest frequency of both agglutinogens *A* and *B*. The frequencies of both *A* and *B* tend to diminish in the races encountered as one travels up the Ganges valley to the north-west frontier. No evidence is adduced to support the theory that agglutinin *A* arose in Europe and *B* independently in India. The authors think it is at least as probable that both *A* and *B* arose in the Indo-African continent, not in man, but in the common ancestors of the anthropoids and man.

17. Hydrogenated oil as an adulterant of milk.

B. B. BRAHMACHARI, Calcutta.

Hydrogenated oils, vegetable products of the market, are being used for adulterating milk-fat directly in the milk.

Ghi prepared before a municipal Chairman from buffalo milk drawn in his presence, another by the Sanitary Inspector, and a third by author, from buffalo milk purchased from vendors, gave Reichert Wollny figures of 15, 24, and 20 respectively.

These values are lower than the legal standard and below the range given by 28 ghis prepared by author, each from genuine milk of a single buffalo. Further, all these three ghis reacted to the test for nickel, a catalyst for hydrogenation of oils. These milkmen, too, were importing vegetable products.

Eight brands of vegetable products were analysed. All showed nickel and had little or very low Reichert Wollny value. Six had saponification value decidedly lower and iodine value and refraction higher than, and two, the same, as those of milk-fat. Iso-leic acid is a useful indicator with some brands but absent in others.

Suspicion for such adulteration of milk should be roused by finding higher Butyrefractometer reading of its fat.

18. How does the agglutinating vibrio of cholera appear during the epidemic of the disease.

B. B. BRAHMACHARI, Calcutta.

Non-agglutinating vibrios are believed by many to be the connecting links between the agglutinating vibrios of the epidemic. But while the agglutinating vibrio has been found to become non-agglutinating, the converse change has rarely been recorded.

In our laboratory we could convert two non-agglutinating vibrios into the serologically typical vibrio of cholera. May not the same change occur in persons harbouring them?

We kept a number of rabbits immunised against non-agglutinating vibrios under observation. We recovered from one of them, after $3\frac{1}{2}$ months, and from another, after over 8 months, agglutinating vibrios; the vibrio from the former reacted to the limit of the titre of the specific serum, and that from the latter, though responding to the titre of $1/2000$, agglutinated with the serum of a cholera patient.

The agglutinating vibrios were evidently the result of transformation of the non-agglutinating vibrios which the rabbits had been harbouring in them since their immunisation.

Presumably the same transformation may occur in the human carriers of the non-agglutinating vibrios accounting for the agglutinating type of the epidemics.

19. Bengal Dyspepsia.

U. P. BASU, Calcutta.

Bengal Dyspepsia—Its importance—Aetiology—Graphic description—Complications—Diagnosis—Differential. Diagnosis—Prognosis—Treatment (Preventive, dietetic, medical and climatic).

20. The social, economic and dietetic aspects of tuberculosis in India.

C. MUTHU, Madras.

Apart from the bacteriological aspect, the social, economic and dietetic factors loom large in the causation of tuberculosis in India.

Among the social factors may be mentioned: The evils of child marriage, purdah, intermarriage within the caste, joint family system, careless spitting. Economic factors include: Low wages, underfeeding, poverty, overcrowding in cities and towns, insanitary conditions, want of fresh air and sunlight. Dietetic factors: Poor or ill-balanced food which contains too little animal protein and excess of carbohydrate, want of nourishing foods such as pure milk and ghee and vitamins. There is a close relation between deficient nutrition and tuberculosis as seen in a large scale during the late war. Other factors include: Fevers like malaria, diseases like syphilis, diabetes, heat and dust, mental stress and fatalistic temperament, sexual excess. All these by creating nutritional and endocrine deficiency, low vitality and poor soil open the door to tuberculosis.

Remedies :

Social Reforms: Indians by creating an enlightened public opinion can break down such age-long customs as child marriage, purdah, indiscriminate spitting.

Social and Sanitary measures: Improved housing, feeding and social and economic condition of the people and raising their standard of living and efficiency will in time reduce the incidence and mortality of tuberculosis as proved in European countries and America.

Sanatorium measures: will help both to arrest the disease especially in the early stage and serve the educational purpose of showing the importance of fresh air, country life and sanitary living.

21. A simple and efficient metabolic cage for rats.

BHOLANATH BANERJEE and S. RANGANATHAN.

The metabolic cage exhibited represents very many improvements, combined with simplicity in design. It is very easy to manipulate. It is made wholly of tin sheet and galvanised iron wire. All parts are detachable, tight fitting and hence easy to clean. The bottom funnel and perforated discs are coated with paraffin once a week to prevent rusting and to obviate loss of urine by sticking to the sides. These parts can better be made of nickel. The water or milk tubes graduated in volumes are new in design and self-adjusting to keep a constant supply at the mouth. It is very cheap and any tinsmith can prepare it. A dozen cages have been in use in our experiments on stone-in-the-bladder for over a year.

22. Description of the larval and adult stages of a new species of anopheles from Bengal.

M. O. T. IYENGAR, Calcutta.

A species of anopheles bred out from larvae collected from streams in the Bengal Duars has been found to be quite distinct from all known species and has been named *A. bengalensis* Sp. Nov. The larval and adult characters of this species and its affinities are discussed in this paper.

23. Certain factors controlling the endemicity of malaria in Lower Bengal.

M. O. T. IYENGAR, Calcutta.

In Lower Bengal, malarious and non-malarious areas exist side by side and as the species of *Anopheles* found in both are identical, and no differences are perceptible in the density of population or other apparent causes, it was found difficult to ascribe the reasons for the difference in the endemicity. This led to an investigation in which several villages with different average spleen indices from 40 to zero were kept under observation and every breeding place in each of these villages was examined once every fortnight for a period of three years. As a result of these investigations, it was found that although there was no difference in the *Anopheline* fauna of the villages, the "monsoon rise" of the carrier *Anopheles* in relation to the transmission season differs in the different villages. In villages with a higher spleen index, the rise occurs earlier than the rise in the less malarious village. When the rise of the carrier species occurs early in the transmission season, malarial incidence is high. Where the rise of the carrier species occurs later, the malarial incidence is reduced proportionate to the delay. In those villages where the rise occurs towards the close of the transmission season and later,

the villages are free from malaria inspite of the presence of the carrier species in large numbers.

The reasons for the early and late rise of these species have not been ascertained.

24. Seasonal Variation in Spleen Indices.

M. O. T. IYENGAR and PANCHANAN SUR, Calcutta.

The spleen index of any rural area is not a constant figure. It has been found that it shows distinct variations which are seasonal. The dry season is the period when spleen index is low, while during the close of the monsoon season and early winter, the spleen index is high, and the difference between the high and low spleen levels is often very great. Besides the large rise towards the close of the year, another rise, a smaller one, occurs in March-April. These seasonal variations have been observed in all types of villages, hyperendemic, endemic and low-endemic, with the exception of the early spring rise which is not felt in the hyperendemic areas. The curve of the average spleen size follows that of the spleen index. The three factors, relapse, rally and infection are responsible for these fluctuations. The results of the monthly spleen censuses of several villages for several years continuously form the basis of this paper.

25. Verne's test.

Z. ANDRE, Pondicherry, French India.

Vernes serum test for diagnosing syphilis, consists in flocculating the specific blood serum by a colloidal reagent known as Perethynol and in estimating the degree of turbidity by a very ingenious apparatus, electrically let, known as V.B.Y's Photometer.

This method has been found superior to all others.

Verne's test is used not only for diagnosing syphilis but also for controlling treatment.

In French India this test has been used for over one year in the bacteriological laboratory.

1159 flocculations were carried out simultaneously with B.W.

Discordancy: Out of 1159 cases, 46 were not in agreement.

They were either Wassermann + and Verne's—

or Wassermann— and Verne's+

After careful clinical examinations we have had to side with Verne's test in every case.

Verne's law—If after methodic treatment Verne's flocculation test is carried out monthly and remains negative for eight successive months we may guarantee that the patient is cured.

26. Intravenous Chemical Treatment of Gonorrhoea.

Z. ANDRE, Pondicherry, French India.

Intravenous injections of gonacrine have given excellent results in the treatment of Gonorrhoea and its complications.

The drug used is the yellow dye acridine (diaminomethyl-acridine hydrochloride) otherwise known as gonacrine.

The mode of treatment is quite simple. An intravenous injection is given thrice a week 5cc. of gonacrine of a 1 in 50 aqueous solution is thoroughly mixed with some blood aspirated and is then injected into the vein.

This treatment calls for no special diet. Gonacrine prevents and cures the complications of gonorrhoea (acute cystitis, orchido epididymitis chronic and acute arthritis).

We treated twenty patients and have never witnessed any violent reaction.

27. Place of musk in Therapeutics.

M. R. GURUSWAMY, J. C. DAVID *and* GOVINDA REDDY,
Madras.

The value of musk in Therapeutics has been studied. It has a pronounced leucocytic effect in cases of leucopenia and as such is useful in raising the tissue resistance. It has the additional advantage of having practically no effect on the leucocytic count of either normal individuals or of those with high grade leucocytosis.

28. A relative instead of an absolute method of measuring statistical significance.

H. H. KING, Madras.

The final interpretation of most biological experiments using animals or plants with controls rests with statistics. So any improvement in the statistical methods used is of the greatest importance to research workers.

The basis of present methods is briefly described. They lead to the evaluation of a summed chance "p" from the size of which a deduction is made as to the probability (or rather improbability) of the hypothesis (of homogeneity) on which "p" was calculated. This is an argument in inverse probability. The principles of inverse probability are discussed and it is shown that P as an absolute measure can be used only with a certain general type of frequency distribution and that even then any one criterion for the use of P has different values for different distributions. It is shown that on the occurrences of a given event the only figure that is proportionate to the probability of any particular hypothesis is the chance of the occurrence of the event on that hypothesis. While this proportionality gives no absolute value of the probability of the hypothesis, it can be used to give the relative probability of two hypotheses by taking the simple ratio of the two chances. By summing the probabilities of all possible particular sampling hypotheses under first the general hypothesis of homogeneity and then of heterogeneity and taking the ratios of the two sums we can get the relative probability of homogeneity to heterogeneity. The similarity of this to Bayes' method and its implications and extensions are discussed.

The expression for the ratio of the average chance of getting two samples on the hypothesis of heterogeneity to that of getting them on the hypothesis of homogeneity which represents the ratio of the inverse probability of the two hypotheses is as follows:—

$$\frac{\frac{2r}{r} \frac{2s}{s} \frac{2(n-r)}{n-r} \frac{2(m-s)}{m-s} \frac{2(n+m)+1}{n+m+1} \frac{r+s}{2(r+s)} \frac{|n+m-r-s|}{|2(n+m-r-s)|} \frac{|n+1|}{|2n+1|} \frac{|m+1|}{|2m+1|}}{\frac{r}{r} \frac{s}{s} \frac{n-r}{n-r} \frac{m-s}{m-s} \frac{n+m+1}{n+m+1} \frac{2(r+s)}{2(r+s)} \frac{|2(n+m-r-s)|}{|2(n+m-r-s)|} \frac{|2n+1|}{|2n+1|} \frac{|2m+1|}{|2m+1|}}$$

29. Filarial survey of Saidapet.

H. H. KING, C. G. PANDIT, K. P. MENON *and*
P. V. SEETHARAMA IYER.

A house to house survey was made in Saidapet from October, 1927 to March, 1928. The findings and their implications are described. Differences apparently due to localities or economic conditions are pointed out. Briefly it was found that 16% of the whole population were found infected and that 6.5% suffered from the disease in some way. The observation that elephantiasis cases harboured few or no microfilaria was confirmed.

The mosquito responsible was found to be only *Culex fatigans*. Of these 1,741 females were caught and dissected. 34.6% were found infected and 9.5% were infective, i.e., contained mature larvae.

As regards other possible sources of infection, some evidence is produced to show that in all probability the source of the infection in these *Culex fatigans* mosquitoes was man.

Differences between localities as regards human infection and disease are discussed. The great similarity of the mosquito infection rate in different areas and houses is contrasted with the dissimilarity of the disease rate in man.

Great occupational differences in the incidence of filariasis were found to exist. They appear to be associated with work and postures that predispose to damage the lymphatics e.g., as in the work of dhobies. Differences in the incidence of filariasis in the two sexes are probably due only to differences in occupation.

30. A note on the source of the filarial infection in *C. fatigans* caught in Saidapet.

H. H. KING, C. G. PANDIT, K. P. MENON AND P. V. SEETHARAMA IYER, MADRAS.

Birds, reptiles and other non-mammals can be excluded because of the absence of nucleated red blood cells in mosquitoes' stomachs. Further, although crows were found to be heavily infected (80% of them) *C. fatigans* could not be infected from them. It is probably not the carrier. A few dogs and calves were found to have slight infections but *C. fatigans* could not be infected probably because of the slightness of the infection. The correlation of infection rates in mosquitoes with microfilaria rates in man in different localities in Saidapet tends to confirm the conclusion that man was the major if not the sole source of infection.

31. The adhesion phenomenon in filariasis.

C. G. PANDIT, S. R. PANDIT and P. V. SEETHARAMA IYER.

The Rickenburg phenomenon of adhesion of leucocytes found in protozoal infections is shown to occur also with mf. bancrofti in elephantiasis—a metazoan infection. Sera from 32 cases of elephantiasis with active disease were examined and 78% were found positive. The phenomenon is specific. The importance of the reaction lies in the light likely to be thrown on the mechanism of immunity in filariasis.

32. A new filaria in *Calotes versicolor*—*conspicuum quindien-sis*. n. g.; n. sp.

C. G. PANDIT, S. R. PANDIT and P. V. SEETHARAMA IYER.

A new filaria found in *Calotes versicolor*, the common "blood-sucker" is described. It belongs to the sub-family MICROPLEURINAE, and it is proposed to create a new genus and new species to include it. The paper gives a full description of the adults and the microfilaria.

33. The life cycle of *Conspicuum quindiensis* n.g.; n. sp. (1928) in the intermediate host *C. fatigans*, with a survey of filariasis in the lizard, (*Calotes versicolor*).

C. G. PANDIT, S. R. PANDIT and P. V. SEETHARAMA IYER.

The development of the microfilaria of *C. quindiensis* to the mature larvae in the intermediate host *Culex fatigans* is described. The survey

brings out chiefly the following two points,—(1) high incidence of infection in “wet” as compared with “dry” areas, (2) progressive increase in the incidence of infection with weight (*i.e.*, age?).

34. Immunological reactions with helminthic antigens.

C. G. PANDIT and S. R. PANDIT.

Rabbits and fowls were immunised by the injection of extracts of *C. guindiensis*. The antigenic response is discussed in relation to adult worms, microfilariae, and fully developed larvae from the intermediate host.

35. A report on a rat flea survey of Hosur, Salem district.

P. V. SEETHARAMA IYER.

A rat flea survey of Hosur was carried out during September, 1928 as part of a programme of investigation designed to study the geographical distribution of rat fleas in the Madras Presidency. Drs. N. Natarajan and P. V. George who were going to carry on similar surveys under the Indian Research Fund Association assisted in this first survey. A summary of the results is given.

Rats.

(1) The density of the rat population is high, 35 rats being trapped on an average for 100 traps laid.

(2) Two varieties of *Rattus rattus*—the brown bellied and the white bellied—are present, 75% belonging to the latter variety.

(3) Nearly 70% of the rats obtained were females.

(4) Groundnuts and cakes made of the local grain, Ragi were found to be efficient baits.

(5) 200 trapped rats were examined for any signs of plague with negative results.

Fleas.

(1) Five thousand four hundred and seventeen rat fleas were examined, all excepting three belonged to the genus *Xenopsylla*—the three Indian species of *Xenopsylla* are present.

(2) *Pulex* occurs in houses but was not found on rats.

(3) More than 60% of the fleas collected were males. *X. cheopis* and *X. brasiliensis* showed a high proportion of males, the distribution of sexes in *X. astia* being irregular.

(4) *X. brasiliensis* is the predominant flea of Hosur (62.8%), *X. cheopis* coming next (28%).

(5) The general flea index—number of fleas per rat—is 13.6, while the specific flea index for *X. cheopis*, *X. brasiliensis* and *X. astia* is 3.8, 8.5, and 1.2 respectively.

(6) All rats trapped, except one, had fleas on them—69% of rats had all the three species. Almost every rat was *cheopis* infested.

36. Some observations on the water of the Red Hills Lake.

T. N. S. RAGHAVACHARI and S. V. GANAPATHY IYER,
Kilpauk.

In the present paper, the temperature of the water, the action of sunlight and the food material present in the water of the lake together with the resulting depletion of the dissolved oxygen content are dealt with.

The more important findings arrived at from a study of the above factors extending over a period of over three years are summarised below:—

- (i) The temperature of the water varies widely with the season of the year.

- (ii) The action of the powerful tropical sun brings about a stratification in the water of the lake, an increase in the algal and other growths which decay and settle to the bottom.
- (iii) The decayed and decaying material and the faecal pollution washed into the lake during the rains, bring about bacterial activity of the anaerobic type resulting in a progressive decrease of the dissolved oxygen content of the water.
- (iv) The depletion of oxygen, it is suggested, is largely responsible for the production of tastes and odours in the water, particularly when favourable conditions are established in the filters.
- (v) Samples of water from the Kilpauk end showed a further slight decrease in their dissolved oxygen content, and after artificial aeration were found to take up from 7 to 30% more of oxygen, varying with the season of the year.
- (vi) The raw water contains a thoroughly representative gathering of microscopic animal and vegetable life. A few species of the blue green algae and chara which are known to produce sulphuretted hydrogen when they decay and putrefy, are present in abundance.
- (vii) An extended study should be made of the limnology of the lake in all its aspects.

37. Group agglutination in Paratyphoid fever.

K. S. RANGANATHAN, Guindy.

The paper deals with an investigation of 28 cases of fever in a school girls' hostel at Cocanada. The diagnosis was based on blood cultures and Widal test. *B. Paratyphosus* A was cultivated from the blood of two patients during relapses. The causative organism could not be isolated from the blood of the other patients as they came under observation late in the disease at a time when the peripheral blood is usually sterile. But it is likely that all the cases were due to Paratyphoid A infection as clinically the disease was the same as is apparent from the temperature charts which will be exhibited. Further, the patients were living under identical conditions. The question of a possible mixed infection is discussed.

The Widal reaction was obtained in every case and at first sight were diagnostic of typhoid fever. Thus against *B. Typhosus*:—

8 reacted in 1 in 200.
10 „ in 1 in 100.
9 „ in 1 in 50.

Some cases gave a high positive agglutination with Paratyphoids A and B as well as *B. Typhosus*.

Para A.

8 reacted in 1 in 50.
4 „ in 1 in 25.

Para B.

19 reacted in 1 in 50.
2 „ in 1 in 25.

In the routine Widal test the highest dilution of serum put up for the Paratyphoids is 1 in 50.

It was suggested by Lt.-Col. H. H. King that the end-point of these sera be found out. Accordingly 24 sera were tested with the following results:—

	+400	+200	+100
<i>B. Typhosus</i> .	8	13	3
<i>B. Paratyphosus</i> A.	2	8	7
<i>B. Paratyphosus</i> B.	—	1	5

The high positive reactions with *B. Paratyphosus* A are apparent. In one patient the end-point for *B. Paratyphosus* A was 1 in 400 while that for *B. Typhosus* was only 1 in 200. The Widal test had to be done more than twice in some patients and an analysis of these results shows :—

1. That primary agglutinins for *B. Paratyphosus* A do not develop to a high degree until late in the disease, sometimes not until convalescence.

2. That their curves may not rise as high as those for *B. Typhosus*.

For instance in the two cases from which *B. Paratyphosus* A was isolated from blood the end-point for *B. Paratyphosus* A was only 1 in 200 while that for *B. Typhosus* was 1 in 400. This finding is not in agreement with the belief that the agglutination for the specific organism is always much higher than for group agglutination organisms and will have to be remembered when interpreting the result of a Widal test.

38. Classification of Lactose-fermenters by serological methods.

T. SEETHAPATHY, Guindy.

In a preliminary paper read at the Science Congress, Lahore, in the year 1926, it was pointed out that it had been possible to classify Lactose-fermenters into two groups, Human and Bovine, by the application of specific agglutinating sera prepared against Coliform-organisms isolated both from faeces and cow-dung.

The finding has, on the present occasion, been confirmed by testing over 1,000 Lactose-fermenters by the polyvalent agglutinating serum specially prepared against Coliform-organisms.

From a series of specimens of earth taken from soils from different sites, Lactose-fermenters were isolated and subjected to agglutination test against the two types Human and Bovine. It was found that 97% belonged to the non-agglutinating type while 3% was distributed between the Human and Bovine. Thus a third type belonging to Soil could be identified.

Specimens from the excreta of rabbits, guinea pigs, monkeys and pigeons were bacterially analysed, the Lactose-fermenters thus isolated having been examined against the stock Human and Bovine type of serum. A large number of them 97.5% have not reacted to either thus falling in the group "Soil-Coli."

The classification has then been applied in a very small measure to water samples. Thirty samples of unfiltered and filtered quality were examined with the result that 14 showed Lactose-fermenters of Human type mixed with others, seven of Bovine type mixed with the soil kind and nine of soil type only.

Summary :—

1. Three types of Lactose-fermenters can be differentiated by specific coli serum—Human, Bovine and Soil.
2. Each type of Lactose-fermenters is normally present in very high proportion in the particular pabulum denoted by its name.
3. This classification would become a useful standard for application in detecting the pollution of waters more pointedly, than the existing standards which do not afford any conclusive evidence.

39. Two simple and useful remedies.

MAJOR LABERNADIE, Pondicherry, French India.

I—METALLIC IODINE : Oral administration with milk in the following manner :—

Metallic Iodine	2 grammes.
Glycerine	{	aa	..	15 grammes.
Alcool 60%	{	aa	..	15 grammes.

five minims three times a day to begin with and increased by 3 minims each day up to 100, 150 minims pro die, has given excellent results in the undermentioned diseases :—

- (a) *chronic rheumatism*, with or without hyarthrosis, has shown quickly marked improvement,
- (b) pyrexial attacks of *malaria* are distinctly lowered,
- (c) the general condition of *typhoid* patients is upheld,
- (d) *asthmatic* attacks are lessened.

In the latter case, oily preparations of Iodine (e.g., Lipiodol) in hypodermic injections are preferable to oral administration and have proved very successful in our hands.

II—CALCIUM CHLORIDE : In high doses (minimum per day : for children, 5 grammes ; for adults, 10 grammes) is a very valuable drug in oedema and exudations—oral administration in concentrated solutions, followed by a highly flavoured syrup to dissimulate its nasty taste, is well borne by patients.

It should be given in series during 4 or 5 days at a time.

Oedema due to renal trouble—ascitis from cirrhosis of the liver—disappears rapidly.

However, calcium chloride acts only in cases of sodium chloride retention. Consequently, calcium chloride should not be given in cases of oedema due to cardiac troubles.

When ascitis is combined with syphilis, needless to say we use intravenous injections of cyanide of mercury, besides calcium chloride. In cases when novarsenobenzol is indicated we dissolve it in the cyanide. The solution turns brownish-black but it is well tolerated by patients. *This combination has always given us excellent results.*

40. Treatment of tuberculosis by methylic antigene and its control by Prof. Vernes' tuberculo-reaction.

MAJOR LABERNADIE, Pondicherry, French India.

Notwithstanding R. Koch's unsuccessful attempts to cure tuberculosis by the use of Tuberculin, learned men never lost hopes of attaining that end by the use of T.B. or its more or less modified extracts. Among the more recent modes of treatment, the excellent results obtained by the use of Antigene of Boquet and Negre, of the Pasteur Institute (Paris), are worth being recorded.

This product is obtained by macerating T.B. in methyl alcohol and then filtering. This alcoholic extract is meant for hypodermic use twice a week. To start with, the extract should be diluted ten times ; later on, it can be used pure. The doses should be increased by $\frac{1}{4}$ cc., only.

The results of experiments carried on at Pondicherry corroborate those noted in the hospitals at Paris.

(a) *External Tuberculosis* :—Tuberculosis of glands, bony tissues and joints are cured by the above treatment within about three months.

(b) *Tuberculosis of the Lungs* :—When the general condition of the patient is still good and fever moderate, he is sure to secure a radical cure but this will need more time than stated above.

In every case treated, rectal temperature should be carefully taken twice a day. A slight febrile reaction usually occurs after each injection. The next injection should only be given when this reaction has ceased. The doses should be prudently increased. A higher dose should be given only if the last febrile reaction has been very slight, whereas the same dose should be repeated if the febrile reaction has been somewhat high, and continued until such time as the patient's usual temperature remains unaltered or lowered.

A mixture containing 30 to 50 centigrammes of calcium hypophosphite pro die, during ten days out of twenty, forms a good adjunct to the treatment.

This drug which was much used during the middle of the 19th century by the English physician, Churchill, seems to be the best way of fixing calcium in the tissues.

41. Treatment of tuberculosis by methylic antigene and its control by Prof. Vernes' Tuberculo-Reaction.

MAJOR LABERNADIE, Pondicherry, French India.

(Concluded.)

At Pondicherry, every tubercular patient undergoing treatment remains under serological supervision. Once a fortnight Vernes' Tuberculo-Reaction is carried out on them to note the progress of the treatment.

This specific reaction consists in noting that the patient's serum turns turbid in vitro on adding a watery solution of resorcine (1.25 per cent.) and in estimating that turbidity by means of a photometer of precision (the very same one as that used for the control of syphilis).

The figures thus obtained each time form a diagram which expresses the variations of the disease, owing to the specific nature of the reaction.

All our cured cases showed fairly high figures at the beginning, as noted by Vernes' Tuberculo-Reaction with resorcine, and these figures gradually came down to normal by the Methyl Antigene treatment.

42. A case of profound anemia treated by raw liver (Whipple's method).

MAJOR LABERNADIE and Z. ANDRE, Pondicherry, French India.

Pernicious anemia has always been held difficult to treat, hence its prognosis too has been thought unfavourable. Other forms of anemia of lesser importance are likewise very difficult to cure. Consequently, the attention of the whole scientific world has been aroused by WHIPPLE'S method. This learned American has shown by definite experiment that an excessive production of R. B. cells could be brought about fairly rapidly by feeding man on mammalian liver. The results obtained were so marvellous, that WHIPPLE thought he had discovered a specific treatment for pernicious anemia.

MINET and MURPHY of Boston (U.S.A.) followed by AITOFF, LEWY and WEIL in France,—by ANDERSON and SPRIGGS in England and by many others have confirmed WHIPPLE'S discovery by numerous experiments.

The very simple treatment consists in feeding the patient on 200-250 grammes of raw mammalian liver (the liver could be minced and par-boiled). The liver of poultry or fish (even that of cod) is ineffective. The treatment should be kept up for a certain length of time and it is very well borne by patients. Blood counts taken from time to time show the good results obtained.

The above named scientists made use of calf or ox liver. But in India, where the people are much attached to their religious beliefs, the use of ox liver could not be generalized.

Having had to treat a Hindu suffering from a serious form of anemia, we ordered him to feed on sheep's liver and we have obtained satisfactory results.

WHIPPLE'S method was started on the 9th June, 27 by feeding the patient daily on 250 grammes of sheep's liver minced and parboiled. Twenty days later he had gained 2 lbs. and 500000 R. B. cells (blood count: 2,200,000).

In September that is to say three months after the treatment he has gained in all 9 pounds and had more than 3,000,000 R. B. cells.

His general condition was excellent. The patient thought he was cured and left off the treatment.

We saw him again in August 1928. He said his weight had been increasing steadily till the end of 1927, when he reached 99 lbs. (a total gain of 24 lbs.) and that afterwards he had been losing gradually again.

In August 1928 his weight was only 86 lbs. Blood count : 1,500,000.

Wassermann negative.

Vernes' Tuberculo-reaction with resorcline negative.

We started him once again on WHIPPLE'S method.

After a lapse of a month and a half (10th October) he had gained 8 lbs. (weight—95) and two millions and half of R. B. cells (Blood count : 4,000,000).

This treatment is being maintained.

43. The standardisation of X-Ray-Therapy-Dosage upon the Indian skin.

SUBODH MITRA, Calcutta.

A short historical sketch of the development of Roentgen Therapy is given. The experiments were carried out with the special Stabilivolt Roentgen-Therapy Apparatus, which was designed particularly to suit the tropical climates of India. The Physical and biological aspects of the Roentgen rays are discussed. There are various standards of Skin-Erythema-Dose as advocated by Radiologists of different lands. The Seva-Sadan standard of Skin-Erythema-Dose is one having reddening of the skin with slight raising of hair-papillae within 3 or 4 days after irradiation, the erythematous condition turning into bronzing within 7 days, and ultimately leading into deep pigmentation. The Skin-Erythema-Dose of Seva-Sadan standard was obtained in 18 minutes working with, 180 K.V., 4 M.A., 0.5 m.m. Cu + 1m.m. Al. Filters, and 30 c.m. Focus-Skin-distance. The intensity of Roentgen rays was measured by Holzknecht's Radiometer with S. N. Pastille and also by Iontoquantimeter of R.G. and S. A deep percentage dose under 10 c.m. water has been worked out. This is about 30% of the dose absorbed by the skin.

44. Midwifery in ancient India.

SUBODH MITRA, Calcutta.

It has been mainly divided into two periods viz., (1) Vedic Period, (2) Old Indian Period.

Vedic Period. Good references of healing art are found in the Atharva Veda Upanishads and in the Mahabharata. In Atharva Veda, there are Charms to ensure conception, to obtain a male child, to prevent miscarriages, to have easy parturition, and also incantations to make a woman sterile. In Garbha Upanishad, there is a detailed description of Embryology.

Old Indian Period. The monumental work of Sushruta, Charaka and Bagbhatta give the most important information about Midwifery. The Bower manuscript also supplies some information. In Sushruta, a description of the Anatomy of Pelvis, development of Ovum, and Pathology of Pregnancy and Labour is given with the most accurate clinical details. Obstetric Instruments and operations are also described elaborately.

45. Results of Radium Treatment in Carcinoma Corpus-Uteri.

SUBODH MITRA, Calcutta.

Most of the cases have been traced from the University Women's Hospital, Charité, Berlin. These cases were treated exclusively with

Radium during the years 1917 to 1923, thus having a clear margin of 5 years' duration after the treatment. Both the clinical and pathological aspects of the cases have been considered. Intra-uterine applications of Radium tubes were made averaging about 2400 milligram-hours per sitting, and repeated again within 7 days. In the series of cases 23% of patients were completely cured by Radium treatment only.

46. Some observations on the pharmacology of Cardiazol.

J. CHRISTODOSS DAVID and C. VAREED.

Cardiazol is a German synthetic product, being a penta-methylene tetrazol. Much of the literature on this is in German and as the drug is widely advertised in India, a study of its pharmacology was deemed advisable.

The most prominent action of Cardiazol is on the central nervous system. It stimulates the central nervous system in general and causes convulsions by acting on the medulla and the spinal cord. It has been noticed that doses required to produce stimulation of the heart and respiration have also a tendency to cause muscular twitchings and convulsions.

Cardiazol greatly stimulates respiration not only the rate but also the amplitude being increased. This effect is more or less constant.

The stimulation of the heart obtained with Cardiazol is transient and the doses necessary to produce this effect on experimental animals seem to be too large compared with the weight of the animal used, being almost the same as the advertised therapeutic dose for human beings. No permanent damage to the heart is observed even after massive doses.

47. A preliminary note on the characters of the causal organism of Bovine Lymphangitis and its relationship to *Bacillus pestis*.

V. KRISHNAMURTI AYYAR, Madras.

The author records in this paper his further observations on the characters of the causal organism of bovine lymphangitis and compares them with those *B. pestis*. The observations so far made indicate that the organism is very closely allied to *B. pestis*.

From the information furnished by the Deputy Superintendents of the Madras Civil Veterinary Department in 1918 to Mr. F. Ware, the present Director of the Department, in response to a Circular issued by him then and from the list of places from which materials have been received for examination from time to time between 1922-1923 at the Madras Veterinary College Laboratory, the author finds that in the districts where plague is endemic bovine lymphangitis is very rare if at all prevalent and where bovine lymphangitis is endemic, plague has been found very rare.

So striking is the endemic distribution of the two diseases that its significance cannot be overlooked or explained away as a strange coincidence. The author however considers that further investigation is essential before it can be definitely confirmed that the endemicity of the two diseases exists in the form he has recorded in the paper. At this stage the author can only say that this strange endemicity of bovine lymphangitis might be due to the presence or absence in particular districts of particular vectors as transmitters of the disease and that if the organism of bovine lymphangitis is found by further observations to be identical with *B. pestis* this significance will have a very important bearing upon the epidemiology of plague.

48. Studies in Bovine Lymphangitis. (Further observations.)

V. KRISHNAMURTI AYYAR, Madras.

In a paper published as one of the Memoirs of the Department of Agriculture in India, Volume 4, No. 2, 1927 entitled "Studies in Bovine Lymphangitis" the author has discussed in detail the conclusions arrived at by Holmes, Raymond, and Sheather who investigated the disease in India. At about the same time, Daubney in an article entitled "Bovine Lymphangitis or Tropical Actinomycosis" published in the Journal of Comparative Pathology and Therapeutics, September, 1927, described an outbreak of a disease that occurred in Kenya in 1925. His conclusions were that the disease was due to an actinomycosis and that it was identical with that met with in India. After a perusal of this article the author thought it necessary to record further the observations made by him with regard to some of the aspects of this disease.

Between 11-8-25 and 1-10-23, the author had occasion to examine materials sent by the staff of the Civil Veterinary Department collected from different cases from different parts of the Presidency. Details of 173 such cases are given in the form of a statement. These confirm amongst other things the author's original conclusions that the disease manifests itself in most of the cases in a localised affection involving the superficial lymphatic glands of the body and of these glands the precaral glands are affected, most of the prescapular and other glands ranking next in order, and that it is due to a bipolar organism which can be detected in the lesions.

Agglutination tests conducted with available sera taken from experimentally and naturally infected animals against the organism have given positive results.

A vaccine prepared with a broth culture of the organism was supplied to the staff of the Madras Civil Veterinary Department for treatment in 95 cases. In 56 cases out of 72 in respect of which reports have been received, marked improvement has resulted from the vaccine treatment.

49. A note on the treatment of Johne's disease by the intravenous injection of formalin.

V. KRISHNAMURTI AYYAR, Madras.

The author records his observations on the treatment of Johne's disease with the intravenous injection of formalin. The results obtained so far as the particular case treated by him was concerned appear to indicate that though a decided improvement was observed in the condition of the animal treated no curative effect was noticed in as much as Johne's bacilli were found in the rectal washings as well as on the mucous membrane of the intestines after *post mortem*.

The author considers it probable that the absence of any characteristic lesions in the intestines in certain cases in spite of the presence in them of bacilli in numbers is due to a want of resistance of the invaded tissues of the particular individual against the invading bacilli.

He also describes in the paper the method employed by him for the detection of Johne's bacilli in cattle suffering from the disease.

50. The epidemiology of tuberculosis in India.

A. C. UKIL, Calcutta.

The conclusions regarding the epidemiological studies of tuberculosis have been based on (i) Von Pirquet reaction on over 6000 individuals of different ages and professions in rural and urban areas in the provinces of Bengal, Behar, Assam, and Madras; (ii) radiographic observations on individuals of different ages in urban and rural areas and in localised and other forms of tuberculosis; (iii) *Post mortem* evidence (naked eye and

histological) on 1000 consecutive autopsies of hospital cases and 1000 cases of accidental death at the Police Morgue at Calcutta; (iv) the incidence of various types of tuberculosis in a series of 52,500 cases attending the polyclinic of the Calcutta hospitals and on 1400 cases of lung tuberculosis; and (v) tuberculin and other methods of survey in tuberculous homes.

It has been found that the greater part of the population in India are imperfectly immunised, in contrast with the well-immunised individual in Europe, who acquires immunity by minute doses received at infrequent intervals. The whole pathological anatomy as well as the clinical picture and course of the majority of tuberculosis cases in this country can be explained by the theory of massive infection grafted on an imperfectly immunised soil.

51. The role of Secondary Bacterial flora in pulmonary tuberculosis.

A. C. UKIL, Calcutta.

This enquiry was conducted to find out whether the association of secondary bacteria in 'Open' cases of pulmonary tuberculosis had anything to do with the comparatively rapid pathological changes in pulmonary tuberculosis in India.

Various aerobic and anaerobic bacteria were isolated from the sputum of 40 cases of pulmonary tuberculosis, following a careful technic. They were inoculated into guinea pigs singly as well as in association with each other and with the tubercle bacillus. Control animals inoculated with 0.01 mgrm. of Tubercle bacillus died in 41-45 days showing tubercles in inguinal glands and spleen, whereas nearly 70% of animals who had received both tubercle bacilli and one or more of the secondary organisms rapidly lost weight and died in half the period. Haemoculture from the autopsied animals was invariably negative. Some of the obligatory anaerobic bacteria isolated were found to have a moderate degree of pathogenicity.

52. Types of tubercle bacilli isolated from cases of surgical tuberculosis.

A. C. UKIL, Calcutta.

Out of 110 cases in which pus was obtained from non-pulmonary lesions, 45 strains of Tubercle bacilli have thus far been isolated. Of these 9 strains have been isolated by direct culture of the pus on Dorset or Petroff medium.

Almost all the strains have been found to belong to the Human type. Two or three of them seem to have an intermediate degree of virulence between Human and Bovine types. But none of them has as yet shown the generalised lesions in lungs, kidneys and lymphatic glands as produced by true Bovine Tubercle Bacilli.

53. On the applicability of the B.C.G. Vaccine (Calcutta) in the prevention of tuberculosis in India.

A. C. UKIL, Calcutta.

Two series of experiments were carried out:—

(1) To have experimental evidence regarding the stability and virulence of the strain, and (2) to determine the class of individuals suitable for inoculation with such vaccine in India.

The experimental data are given and the field for applicability of the vaccine in the prevention of tuberculosis among an imperfectly immunised general population in India has been indicated.

54. The variations in titre of the serum of cholera convalescents, with a note on the possibility of its therapeutic application.

A. C. UKIL and S. R. GUHA THAKURTA, Calcutta.

Sera of cholera cases were collected at various intervals after the setting in of the reaction stage and their agglutinative and bacteriolytic titre were studied. The experiments in vitro were followed by experiments in vivo (protective and curative) on rabbits inoculated with lethal doses of Koch's vibrios.

This series of experiments was followed by a therapeutic application of the serum in various types of cholera cases. The results are embodied in the paper.

55. Problems and difficulties in the preparation and standardisation of therapeutic sera in India.

H. GHOSH, Calcutta.

The paper deals with the different therapeutic sera which have been produced and are being used in India and discusses points in the production of antisera under tropical conditions including the selection and care of animals.

Theuses of concentrated anti-sera are considered and suggestions made in connection with the problems of their supply and the difficulties of their production in the Tropics.

The keeping properties as regards titre of such sera in India is discussed. The necessity of state control of the supply and assay of Biological products is drawn attention to and the adoption of an international standard for the potency of such sera considered.

56. A preliminary note on an epidemic of superficial punctate keratitis.

R. E. WRIGHT, K. KOMAN NAYAR and STAFF OF THE GOVERNMENT OPHTHALMIC HOSPITAL, in collaboration with H. H. KING, Guindy, J. H. THEODORE and P. S. RAMAKRISHNAN, Madras.

Grüter and Löwenstein showed that the vesicular fluid from Herpes febrilis corneae may produce keratitis and encephalitis in rabbits. H. febrilis corneae (vel H. simplex), dendritic ulcer and H. Labialis have been regarded as clinical varieties of the same affection. Superficial punctate keratitis was not generally so regarded although Fuchs recognised a resemblance, and Verhoeff (1911) emphasised it and further considered all these corneal affections, together with K. disciformis (Fuchs) were typical neuropathic affections. He accepted the clinical description of S.P.K. by Fuchs. Herbert (1901) described an epidemic of S.P.K. in Bombay with an associated organism in the corneal epithelium. Verhoeff held that Herbert's cases showed minor differences from the type description. Kirkpatrick (1920) described a macular keratitis in Madras. It is met with annually in limited numbers. Paton (1926) summarised the position as to H. febrilis; stated that its common form is dendritic ulcer and that H. ophthalmicus is not necessarily in the same group. Levaditi (1927) considered that all forms of Herpes corneae may etiologically be grouped with the neurotropic ectodermoses e.g., encephalitis lethargica, rabies, vaccinia, etc. The epidemic referred to in the title was first noted about May 1928. Over 500 cases have been seen. Obser-

vations show that some clinically resemble the type description, but most early cases resemble those of Herbert. When followed up some assume the character of *K. Maculata* (Kirkpatrick), others that of *K. disciformis* (Fuchs). They do not clinically resemble *H. febrilis*, *H. palpebralis* or *H. zoster ophthalmicus*. Clinical manifestations are described. Microscopic investigations and animal experiments are detailed.

57. Etiology of Leptospirosis icterohaemorrhagica.

D. A. TURKHUD, Kodaikanal.

This epidemic disease, now also called 'Leptospiral Jaundice' was formerly known under various names, such as, 'Toxic Jaundice,' 'Camp Jaundice,' 'Infective Jaundice,' 'Weil's Disease,' etc.

The causal spirochaete, discovered by Inada and Ido, is now, on account of its peculiar spirally twisted appearance, named *Leptospira icterohaemorrhagiae*. Morphologically similar leptospirae are found in the Seven-day Fever of Japan, and also in Yellow Fever.

The organisms are present in the blood of a person suffering from infectious jaundice only during the first five days of fever. After ten days they appear in the urine, and may continue to be discharged in this way for a long time. Guinea-pigs can be infected by intraperitoneal or subcutaneous injection of the blood or urine of patients, also by oral ingestion, and even by the direct application of the infective material to the unbroken skin.

Leptospiral jaundice is common in Japan among workers in damp rat-infested coal mines and swampy fields. During the Great War it was met with amongst soldiers serving in trenches along the Western and Italian fronts, and also in the Dardanelles. Epidemics of it have occurred in India and the Andamans.

The *Leptospira* has been found in the kidneys of rats. It is therefore suspected that these animals play an important part in the spread of the disease. The infection is believed to take place through food contaminated with the urine of these animals; but it may occur through the skin. The actual method of transmission of the infection to man in nature, still remains to be investigated. Experiments conducted with the object of determining whether lice and mosquitoes act as intermediary hosts, have yielded negative results.

The exact diagnosis of the disease can only be made by animal inoculation, but even animal inoculations may prove unsuccessful in clinically diagnosed typical cases. The symptoms in a mild epidemic appear like those of Dengue, while in severe cases, they are exactly like those of Yellow Fever. In the Australian epidemic of Dengue, the disease and its transmission showed many points of resemblance to Yellow Fever.

There appears to be a great similarity in the symptoms of the Seven-day Fever of Japan, Dengue, Leptospiral Jaundice, and Yellow Fever, in steadily increasing severity. It is quite possible that all these diseases may be caused by the same original organism; gradual attenuation of the virus may account for the Japanese fever, or a mild attack of Dengue; on the other hand, exaltation of the same *Leptospira*, may give rise to Leptospiral Jaundice, or to Yellow Fever.

The last word has not yet been said about the etiology of these diseases. Unfortunately, Adrian Stokes, Noguchi, and others, while carrying on investigations, have fallen martyrs to Yellow Fever; but it is hoped that other workers will continue the research and solve the problem.

This paper has been brought to the notice of the Congress as a mild epidemic of Leptospiral Jaundice has been going on in Kodaikanal for the last two years.

58. Trachoma and its treatment by chaulmoogra oil.

C. NARAYANIN and P. GOVINDARAJASSAMY, Pondicherry,
French India.

Results of the treatment of trachoma obtained in the Colonial Hospital in Pondicherry by the use of chaulmoogra oil. Most cases of the trachoma were treated by the process adopted by Morax in Paris-Toulant in Algeria-Delannoe in Algeria. The chaulmoogra oil used in the treatment is prepared by the Government Pharmacy in Pondicherry.

After anaesthesia of conjunctiva by 2 or 3 instillations of cocaine the chaulmoogra oil is applied by process of brushing. On turning the lids they are put to touch each other when completely everted. With a swab-soaked in chaulmoogra oil the trachomatous granulations are brushed many times—starting from internal to external angle of the eyes. The brushing is stopped after the appearance of some slight bleeding which is cleaned with some sterilized cotton and the emulsion produced by the oil with tears. Care should be taken not to leave any thing in the palpebral cavity as the small white bubbles which are formed during the treatment are caustic.

Patients are much satisfied by the immense relief they get from this treatment.

On the very first application the secretion, photophobia, heaviness of lids are much influenced; on the whole the improvement is remarkable: in some cases there was regression of pannus—clearance of corneal opacity—and even some times torsal changes.

Besides its curative effect, chaulmoogra oil is recommended for its painless application.

59. Position of Pondicherry with regard to malaria.

C. NARAYANIN, Pondicherry, French India.

Various types of fevers are prevalent in Pondicherry. Among these diseases a heavy toll of mortality have been unduly attributed to malaria. Two years of research work carried out clearly showed the true part played by malaria in the morbidity and the mortality of the city.

The investigations carried out for malarial parasites at bacteriological laboratory often proved to be negative.

The clinical manifestations of acute malaria are very rare among Europeans and Indians.

The scarcity of vehiculating agents in the town has been also decisively proved by investigations (anopheles 0% in the town and 6% in surrounding villages, in the lots of mosquitoes classified recently).

On the other hand, the splenomegalia is also very rare among the inhabitants of the town as it was proved by the medical examinations of a great number of school boys.

Conclusion: The laboratory research and clinical observations show that acute malaria is very rare in the town of Pondicherry.

60. A preliminary study of maternal mortality in Madras Presidency.

N. R. UBHAYA and R. ADISESHAN, Madras.

One of the fundamental requirements in the inception of measures for the amelioration of conditions relating to maternity is knowledge of the mortality from puerperal causes. Public health authorities and workers in charge of maternity relief movements in this Presidency and probably in the rest of India are hampered to a great extent by the lack of such knowledge, as vital statistical records afford only an imperfect picture of the true state of affairs. When this is so, it is inevitable that

information regarding the several factors associated with maternal mortality is still more meagre. A survey of over 5000 confinements has been made in four cities in order to gain a reasonably correct idea of the maternal mortality. Subject to the limitations of such a survey, the paper gives the results of a preliminary study of the different phases of the problem, chief among them being the proportion of confinements in the different age intervals, maternal mortality occurring in the different ages and birth orders, mortality rate from the important puerperal causes and so forth. Still-births and neo-natal mortality are also incidentally discussed.

61. The isolation, enumeration and identification of plague bacilli by cultivation methods.

S. N. GORÉ, Bombay.

Since the author's method of superimposing ordinary agar slopes with blood agar, made the latter medium as readily and easily available as the agar slope itself, a large series of plantings was made on the two kinds of media with equal quantities of saline suspensions containing varying numbers of plague bacilli; and it was found that in a large majority of instances, when there were ten to thirty thousand colonies on blood agar, there was hardly any growth on the corresponding agar slope.

It thus appeared that blood or serum is an essential constituent for the growth of plague bacilli on solid media, especially when small in number. Usual text books on bacteriology make no particular mention of the fact that blood agar is the medium of choice for growing plague bacilli, and the failure reported by several workers in isolating and enumerating these bacilli may now be attributed to the absence of an appropriate nutrient in the solid medium they used.

Identification of the plague bacillus is easily accomplished by the characteristic growth of its colony, its property of producing nitrites but not hydrogen sulphide or indol in peptone culture, and a few fermentation tests such as acid in glucose and mannite, no change in lactose and sucrose.

62. The superimposed blood agar slope.

S. N. GORÉ, Bombay.

In the tropics tubed media are much more serviceable than plated ones, owing to the great liability of the latter to aerial contamination; this susceptibility becomes much greater when the medium contains blood or serum. Blood agar slopes, as ordinarily made, do not serve all the purposes of the plated medium.

The simple device of securing a thin layer of blood agar by pouring it on the ordinary agar slopes instead of in Petri dishes, makes tubed blood agar as readily available as the ordinary agar itself.

The agar slope provides an even moisture-bearing surface for the blood agar, in place of the uneven dry grass surface; in consequence, the blood agar retains not only the red colour but remains serviceable for about ten to fifteen days.

Whereas about 15 cc. are required "to pour a plate," only about 3 cc. are required "to pour a slope" to secure a layer of blood agar about 2 mm. in thickness.

63. A precis of "a few observations on Mycetoma"—a preliminary communication.

A. VASUDEVAN and N. SESHADRINATHAN, Madras.

With a view to investigate the method of infection of mycetoma, attempts were made to cultivate the fungi in various natural media so

that their appearances as they occur in nature may be noted and they may be searched for in fields, forests, etc. Red, white and black varieties of mycetoma were successfully grown on pieces of tender bamboo sticks, prickly pear and soil media and their appearances are described. Arrangements are being made to search for similar growths under natural conditions in the fields, forests, etc., so that the method of infection may be traced.

64. Studies on the development of micro-filaria bancrofti in *Culex fatigans* in relation to season.

S. SUNDAR RAO and M. O. T. IYENGAR, Calcutta.

Laboratory experiments were conducted at Calcutta to determine the development of the micro-filariae, in the body of *Culex fatigans*, by feeding these mosquitoes on filarial cases. These feeding experiments were carried out during different periods of the year, and it was found that the monsoon months July to September were most favourable for the rapid development of a large number of the embryos. During the winter months, on the other hand, the development was very slow and in the dry months hardly any development took place. If the temperature and humidity conditions are made favourable, it is possible to obtain rapid development even in adverse periods. This has been shown by the behaviour of two batches of mosquitoes fed on the same case in February, one of which was kept at room temperature, while the other was placed in a special incubator in which a high humidity and a moderate temperature was maintained. In the former, there was extremely slow development of the embryos which were very few in number while in the latter, development was rapid and profuse. The authors conclude that as with the malaria parasite in *Anopheles*, the most favourable reason for the completion of the mosquito phase of *Filaria bancrofti* is during the monsoon months.

65. The source of secondary infection in filarial lymphangitis.

H. W. ACTON and S. SUNDAR RAO, Calcutta.

During the course of studies on the pathology of filariasis, the authors found that lymphatic obstruction in filarial infection (*F. bancrofti*) is of two types: (1) Chronic obstruction caused by the immature worm damaging the lymphatics, and (2) Acute inflammatory condition brought about by secondary infection. In the latter type which is the more prevalent one, investigations have been carried out to determine the source of the secondary organisms. It has been found that the secondary organisms originate from septic foci in the body, of which several types have been observed. The nature and location of these different types of foci, and their importance in the treatment of the disease are discussed in the paper.

66. Studies in the physical properties of different blood sera viscosity.

R. N. CHOPRA and S. G. CHOUDHURY, Calcutta.

Viscosities of normal and different pathological sera have been determined at the room temperature. It has been found out that the mean value for viscosity of kala-azar serum is greater than that of any other sera studied. The mean values for other pathological sera are also more or less higher than that of normal serum. Increased viscosity in kala-azar serum might be associated with an increase of the concentration of the proteins, but it is not reasonable to assert that the increase is due only to the increased concentration of one or other of the protein constituents of the serum; for it is well known that a difference in the con-

centrations of the salts, in the states of aggregation of the proteins, and in the pH value can also affect the viscosity of the medium. From the point of view of diagnosis, these determinations are also not of much use, for the variations in the viscosities of sera from the blood of several patients suffering from the same disease are also great.

67. On the causation of formal-gel reaction in kala-azar.

R. N. CHOPRA and S. G. CHOUDHURY, Calcutta.

It has been shown in this paper that gel-formation and development of opacity in kala-azar serum on the addition of formalin depend on the pH of the medium. For a particular kala-azar serum, there is a definite pH at which the times of gelation and complete opacity with formalin are minimum. In some cases they occur at the pH value 6.94 and in others at the pH value 7.27. It has also been observed that the rate of decrease of opacity is much greater than the rate of decrease of gelation on the alkaline side, whereas the rate of decrease of gelation is greater than the rate of decrease of opacity on the acid side. Moreover, by simply diluting the serum with equal volumes of different diluents, we can reverse the order of the processes of gel-formation and development of opacity with formalin i.e., in a diluted serum, sometimes gelation precedes opacity, and sometimes opacity precedes gelation, and this fact can be explained on the basis of a change of pH. These facts have, however, been overlooked by previous investigators and in order to explain them, we have to assume that the processes of gel-formation and development of opacity are caused by two different proteins. The protein or rather the state of the protein, which is responsible for gel-formation has its iso-electric point situated at a pH near about the point of neutral reaction. The other variety, which is responsible for opacity has the iso-electric point 5.5. When we say two different proteins, we mean that they are different in states of aggregation or in the arrangement of the component groups of the protein. We, however, put forward the hypothesis with some diffidence, since we know that a reaction, of formalin with the protein responsible for opacity, might change its nature to a remarkable extent and this might as well explain the observed facts, though with some difficulty. This last point is under investigation. The aldehyde test for kala-azar can be explained on the basis of increased concentrations of the proteins and of their smaller buffer action.

68. Pseudo-ephedrine in pharmacology and therapeutics.

R. N. CHOPRA, B. B. DIKSHIT and K. VENKATACHALAM
PILLAY, Calcutta.

A number of species of ephedra grow abundantly in the drier regions of the Himalayas. A few species also grow in the plains but these contain little or no alkaloids. Two varieties of ephedra grow side by side in the mountain ranges bordering on the Jhelum valley in Kashmere; these are *E. vulgaris* and *E. intermedia*. The alkaloidal content of the latter varies from 0.2 to 1.0 per cent. of which 0.025 to 0.056 is ephedrine and the rest pseudo-ephedrine. The former contains about 0.8 to 1.4 per cent. of total alkaloids about half of which is ephedrine and half pseudo-ephedrine.

Although a lot of attention has been paid to ephedrine during recent years and it has been used largely in therapeutics, its dextrorotatory isomer pseudo-ephedrine has been comparatively neglected. Ephedrine is a very expensive drug costing Rs. 800 per pound and its clinical use is limited by reason of its costliness. The authors investigated the pharmacological action of pseudo-ephedrine with a view to its employment in therapeutics. The action was in the main the same as ephedrine though it was less powerful. A liquid alcoholic extract was prepared

from the crude drug, containing both the alkaloids and was used in the treatment of asthma and as a cardiac stimulant with encouraging results. Pseudo-ephedrine relieves paroxysms of asthma in the same way as ephedrine does. The alkaloid is less toxic than ephedrine and its side effects are not so marked. The use of this alkaloid in the treatment of disease as well as that of the liquid extract will bring down the price of ephedrine.

69. A case of bovine tubercle bacillus infection in man in India.

M. B. SOPARKAR, Bombay.

In European countries where tuberculosis among cattle is prevalent a large proportion of cases of surgical forms of tuberculosis, especially among children, is found to be caused by the bovine bacillus. In certain places, however, where the disease among cattle has considerably diminished this form of disease among children is also said to have become very infrequent. In India tuberculosis among cattle is generally held to be rare but the surgical forms of disease in human beings occurs in nearly the same proportion as it does in England. In a paper read before this section in 1925 result was noted of investigation of 65 cases of tuberculosis, 48 of which were of the surgical type. In no instance was bovine type of tubercle bacillus detected and the bovine bacillus was therefore believed to play no important part in the causation of human disease in India. In the course of further investigation of the subject one of the strains recently isolated from a case of tuberculous cervical glands from a girl in Bombay was found to be of the bovine type.

This is the first instance to be recorded in which the bovine tubercle bacillus has been isolated from a case of human tuberculosis in India and is of interest in connection with another recent finding, the comparatively high incidence of tuberculosis among cattle in some parts of India.

70. Tuberculosis among swine in India. A note on investigation into the prevalence of the disease and the types of bacilli causing it.

M. B. SOPARKAR, Bombay.

Out of 245 pigs examined at the Municipal slaughter house in Bombay evidence of tuberculous infection was detected in 10 i.e. 4 per cent. of the animals. The lesions in most cases were restricted to the submaxillary glands but in one instance generalised infection was present. Eleven strains were isolated and studied—two being from one animal. Ten of these were found to be of the human type and one was bovine. The result is in marked contrast to the findings in America where a very large proportion of cases of disease in these animals is found to be caused by the avian bacillus. As pigs are susceptible to all the three types of tubercle bacilli, viz., human, bovine, and avian, the nature of infection in these animals indicates in some measure the kind and the degree of infection prevalent in the locality from which they are obtained. As the batch of animals examined came for the most part from the suburbs of Bombay and the neighbourhood it follows that the most common infection in that part is of the human type and that bovine infection also exists in the locality.

71. On body surface area and vital capacity standards for Indians.

S. L. BHATIA, Bombay.

The vital capacity of the lungs of 100 normal Indian (males) of the adult age-group was estimated. The standing height, sitting or stem

height, body weight and chest circumference were also recorded. The body surface area was obtained from weight and standing height. For this purpose the graphic chart of Boothby and Sandiford based on the formulæ of Du Bois and Du Bois was used. The theoretical normal body weight according to height and age was also obtained from the Tables worked out by the Association of Life Assurance Medical Directors and Actuarial Society of America. The actual figures for vital capacity obtained in each case were compared with the theoretical normal standards as given by Myers. The result showed, that there was a close similarity between the percentages obtained from the standing height and body surface area standards. There was much variation when standards based on sitting height, chest circumference and body weight were employed.

It was observed, that the vital capacity of the lungs in this group of 100 Indians was much smaller than that of western people. The figures for Indians correspond to a certain extent with those obtained for the Chinese by Foster and Hsieh.

The need for further investigation with a view to establish normal standards for Indians is emphasised.

Certain medical and surgical affections, in which application of the vital capacity test is indicated, are briefly referred to.

72. Some observations on the urea concentration test of McLean and De Wesselow.

S. L. BHATIA, J. D. DUNDAS *and* (MISS) S. M. COOPER,
Bombay.

This test was applied to 38 normal persons, of whom 20 were males, 12 females (non-pregnant) and 6 females (pregnant), with a view to ascertain normal standards for Indians owing to possible differences as compared with English figures depending on different dietetic habits and climatic conditions. 15 grms of urea dissolved in 100 cc. of water were given by mouth. Urine was passed at intervals of one hour and two hours afterwards. The volume and percentage of urea of each sample were examined. The urine was carefully tested for albumin and casts prior to the administration of urea and the percentage of urea in this sample was also estimated. It was observed that:—

- (1) The average percentage of urea in the second hour sample is well above 2. Hence, the power of the kidneys to concentrate urea is as good in the Indian as in the European.
- (2) The percentage of urea in the urine sample prior to the test is relatively low, the average being 1.33%. This is probably due to the low protein diet of the Indian.
- (3) The volume of the second hour urine sample after the administration of urea is generally lower in the Indian than in the European, the average being 53.6 cc. It seldom amounts to 120 cc.

The value of the test in cases of Nephritis is discussed. A case of Malaria is recorded in which the urea concentration test showed lowered renal efficiency.

The application of the test in certain surgical affections of the Urinary Tract is also considered.

73. A simple apparatus for demonstrating and recording the ciliary movements in a mucous membrane.

S. N. MATHUR, Lucknow.

74. A further note on a simple method of testing the strength of quinine stock mixture.

J. W. D. MEGAW, Madras.

75. The treatment of cholera.

R. RAMACHANDRAN, Madras.

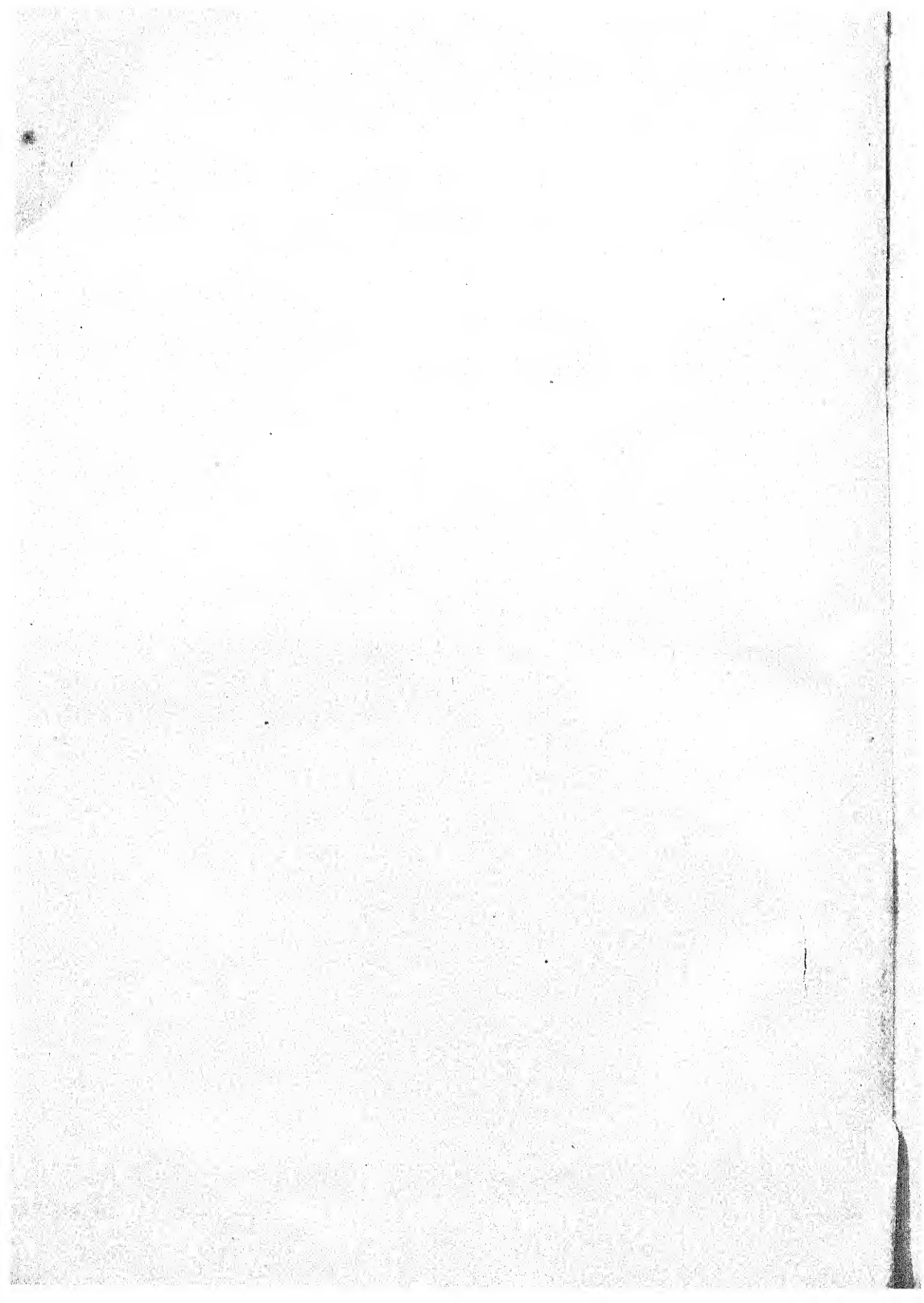
It is suggested that Tomb's mixture is of little use either alone or in addition to Rogers' treatment. Hypertonic saline is the best combative to collapse. Rogers' saline exaggerates "reactionary" fever. It is considered that exo. toxin is responsible for loss of fluid and endotoxin for toxæmia. The reasons are suggested. Permanganates are best given early. After toxæmia sets in, this treatment is of little value. Antiserum may combat toxæmia, but may not avert collapse. In a series of 20 cases iodine appeared to combat toxæmia, but no definite conclusions can be drawn from this observation. The "reaction stage" might better be called the stage of toxæmia. Complications are easier to prevent than the cure. In uræmia it is considered that alkaline solution, weaker than at present employed should be used.

76. Fevers of Madras.

M. R. GURUSWAMI MUDALIAR and S. RAMAKRISHNAN, Madras.

A classification of the fevers as seen in the General Hospital, Madras during 1927 and 1928 has been made with respect to their etiology.

A careful study of the intestinal group organisms shows that we have in Madras a great preponderance of *B. Typhosus* and that Infection with the allied group organisms are extremely rare.



Section of Anthropology.

President:—R. B. SEYMOUR SEWELL, M.A., F.A.S.B., F.Z.S.,
F.L.S.

Presidential Address.

THE ORIGIN OF MAN AND THE POPULATION OF INDIA IN THE PAST AND THE FUTURE.

The population of India at the present day is a great heterogeneous collection of races and tribes, of differing physique and in all stages of culture, and if ever this mass of humanity is to be welded together—I do not say into an Indian nation, for at present such a result appears to be beyond the bounds of possibility—and is to assume politically a more or less homogeneous character, a knowledge of the habits, culture, religion and, last but not least, of the physique and bodily structure of the various tribes and especially of “the stranger that is within your gates” or on your borders is of prime importance; and not a mere knowledge only, but a full appreciation of all that those habits, customs and traditions mean to him. To some these customs may appear foolish or a result of ignorance and superstition, a relic of a far off past, but to the individual himself they may be the very essence of his being.

At the present time the study of Anthropology in this country is in its infancy and its importance does not appear to be generally recognised. There are, I believe, only two of all the Universities in India that include the study of Anthropology in their curriculum and even in these two instances far more attention is paid to the study of Ethnology, to the habits, customs and traditions, either religious or mythical, of the people than to their physical or, as I may perhaps be allowed to put it, their zoological relationships. That this should be the case is, when viewed from the standpoint of one who wishes to trace man's evolution, regrettable, since the study of language or customs, no matter how thorough or painstaking, can never reveal to us the actual relationships of the various tribes and races that go to the make up of the population of this great country, nor will it enable us to reach any definite conclusions regarding the origin or the structural evolution of the great mass of the inhabitants that are at the present time living in India.

Viewing the subject from another standpoint, Indians are, very naturally, interested in their past history and are justly

proud of their ancient civilisation. They point with pride to the fact that it is in India that we find some of the oldest civilisations and religions of the world. But the story of India does not begin with the Rig Vedas. Ages prior to the rise of India's great civilisations and cultural achievements, an Indian population was gradually undergoing a process of evolution, starting from the most primitive conditions and progressing steadily onwards and upwards to the stage when history begins and the art of writing brought to a close the stage of purely verbal tradition. The history of India, as we know it to-day, is only the sequel to a far greater history that went before; a history that has left its traces, not in the written word, but in the actual remains of these primitive people and of their implements and utensils; and this history only requires investigation. Throughout the length and breadth of this country there is awaiting discovery a mass of evidence of the most valuable kind that will enable future Archaeologists and Historians to trace the course and sequence of events that led up to and formed the basis on which Indian civilisation and culture was founded. I would, therefore, take this opportunity of impressing on you the necessity of a study of Anthropology both for the Archaeologist and Historian, and especially for the Politician, who hopes in years to come to take part in the administration and government of the various and varied tribes and races of this country.

The origin of the so-called human race is still a matter of dispute. We do not yet definitely know either the time at which or the region where the first pair, the mythical Adam and Eve, from whom the whole of the present population of the world has sprung, made their appearance. We are not even certain that the human race had a single origin. But we do know that, whatever the origin of the so-called genus *Homo*, there are at the present day a number of different races, many of which in their structure differ so greatly from one another that they would be divided by zoologists, if judged by their structure alone, into different species; and, furthermore, we know that in times past similar races have sprung up, only to be gradually eliminated by nature in the struggle for existence.

The place of man's origin is still a matter of uncertainty; some have argued that it was in Europe that the genus *Homo* first appeared, basing their belief in the main on the large number of remains of pre-historic Man that have been discovered in that region. Others have claimed north Africa and especially the region of the Sahara as the site of man's evolution, and a considerable amount of evidence has been adduced in favour of this region; Sergi has claimed it as the site of origin of the Mediterranean race and recently Peake and Fleure (1927) have urged that it is Man's original home. A third locality that is claimed as the site of Man's evolution is the high

land of central Asia, the region where Tibet and the high country to the north lie to-day. Of these three areas the last two have up to the present time received the greatest support; but in the present state of our knowledge it is impossible to arrive at any definite conclusion; and we must also remember that it is possible that each of these views is correct. If we consider Man to be a genus and the different races to be species, then these races or species, like those of other lower genera, may have appeared independently in regions far removed from each other, and though an authority such as Professor Osborn (1927) may ridicule the suggestion and term it "fantastic," yet the possibility remains unchanged.

In other groups of the Animal Kingdom a study of the distribution of the various forms that are living at the present time and of the fossil forms that have previously inhabited the earth, provides us in many instances with sufficient evidence on which to base a conclusion regarding the origin of the group; in this connection I would call attention to the work of Matthew (1915) and of Davidson Black (1925). This latter author in a very able paper has summed up all the evidence that he could collect regarding the place of origin of the human species and he has given very strong grounds for the belief that man must have originated in the centre of Asia. That few fossil human remains have as yet been discovered in this region is no argument against its probability; of all the countries of the world one and only one can be said to have been systematically searched for such remains and that is western Europe; and as a result nearly all the finds of primitive man have been in that region: but, as I have already remarked, that is no proof that man originated there; it merely proves his presence there in large numbers at a very early stage in man's history. Even the small amount of exploration that has been carried out in central Asia and along the northern boundary of India has yielded finds that tend to corroborate the view that central Asia was man's original home or at any rate was one of such homes.

The next question that we must consider is the time, *i.e.*, the period in Geological history, in which Man first came into existence. Here again we appear at present to be unable to form any very definite conclusion. Each succeeding discovery seems to place this origin further and further back in the world's history, but we are on firm ground if we accept the view that man existed, in very much the same form as we know him to-day, at any rate during, if not before, the last Glacial Period. Of one thing all zoologists are perfectly certain and that is that Man belongs to the Primate group of the Mammalia; and whether we regard him as evolved from an Anthropoid stock, or whether we persuade ourselves that the Anthropoids are degenerate forms of some higher and more man-like ancestor,

there can be no doubt of the zoological relationship. Granted this relationship, the next question that arises is, What do we mean by Man? Where are we to draw the line between Man, as we know ourselves to-day, and man as he was at the time of the last Glacial Period, examples of which we have in the so-called human remains of Piltown, the "dawn" man as he is sometimes called (*Eoanthropus dawsoni*), of Heidleburg man, Neanderthal man and other similar primitive forms, or between these primitive forms and the still earlier and more primitive forms like *Pithecanthropus erectus* of Trinil in Java or *Australopithecus africanus* of Rhodesia? As long as we possess only isolated examples such as these, it is easy for us to declare that they represent different species and different genera, but, if we accept the theory of evolution, there was in the process of man's evolution and development no such discontinuity as these solitary remains might seem to indicate; unless we are prepared to believe that man originated by a sudden mutation, it would appear certain that there must have been a gradual modification from one form to another and this process must have taken thousands of years to accomplish, so that, if man, as definite man, existed in Europe during or even before the Glacial Period, and the evidence of the Foxhall flints seems to indicate that man certainly existed in the Pliocene Epoch and had, even by that time, attained to such a stage in his evolution that the hand had become a perfect grasping organ with a completely opposable thumb, we must go a great deal further back than this to reach the time when his evolution from the original stock first commenced. Again, either actual human remains or the remains of human culture have been discovered all over the world in strata that are of undoubted Pleistocene age; such remains have been excavated in the extreme ends of America, Australia, and Africa. In the accompanying figure (Text-fig. 1) I have indicated the sites at which such discoveries have been made and, as can be seen, there can be no doubt that by the close of the Pleistocene Epoch Man had already spread all over the globe, no matter where he may originally have come into existence. We seem then to be on fairly safe ground in thinking that Man must have commenced to evolve from his ancestral stock at least as early as the Miocene period, and Gregory (1927, p. 439) suggests that this evolution commenced in the Middle Miocene Epoch.

Granting then that Man probably came into existence in the middle of Asia and in the middle of the Miocene Epoch, the next question that we must consider is, what was the condition of Asia and especially central and southern Asia during this remote Epoch? Peninsular India is one of the oldest areas of land on the globe and though it has suffered a succession of changes, such as outbreaks of volcanic eruption that covered a great part of its surface with a deposit of basalt,

or a tilting of its level that caused a complete reversal of the flow of some of its great rivers, yet in the Miocene period and for a long time before this Peninsular India was in existence in one form or another and, moreover, in all probability extended very much further to the west than it does at the present day. But immediately to the north the conditions were very different from those of the present time. Hayden



FIG. 1 ; showing the localities in which human remains of undoubted Pleistocene Age have been discovered.

and Burrard (1907-08) have pointed out that "until a comparatively recent date in the geological time scale—the middle Tertiary Epoch—all the northern part of what is now the Himalaya, and probably the whole of Tibet were covered by a great sea." At a later period the floor of this sea was elevated and thrown into folds and now forms the ridges of the Himalayas. Simultaneously with these geological changes and as a result of them there occurred a very great alteration in

the nature of the terrain of central Asia; originally an extremely fertile country, probably with vast primeval forests, the gradual rise of the Himalayas slowly but inevitably cut off from it the rainfall on which its fertility depended. Previously the south-west monsoon had brought with it heavy rain that was distributed over the whole area, but the gradual elevation of a mountain range between the central Asiatic region and the Indian Ocean caused the greater part of the rainfall to be precipitated on the south side of the hills and gradually the fertile area of central Asia became what we find it to-day; as the rainfall diminished the forests slowly disappeared and were replaced by grass lands, and in more recent times even this disappeared and the main area became desert. Such a change must have had a profound effect on the fauna of this region. Forest animals had to become adapted to open country and tree-haunting forms take to a terrestrial existence, or else migrate to other and more suitable regions; failing either of these changes, they must have perished and become extinct. Concomitant with these changes and adaptations, a large number of new species must have made their appearance and it seems probable that it was this change in the nature of the country that caused our ancestors to commence that final phase of evolution that, passing through intermediate stages, probably of the character of such forms as, though not identical with, *Pithecanthropus* and *Australopithecus*, culminated in the appearance on earth of Man.

The early primitive races of Man, that have been discovered in Europe and the near vicinity, appear to have been dolichocephalic or long-headed in their skull type, but later a brachycephalic or broad-headed type made its appearance in this region. The Caspian and Mediterranean races are dolichocephalic as also were their predecessors, Piltdown man, Neanderthal Man and the Cro-magnon race; but on the other hand the Palaealpines, such as the Negritos, and the Alpines are brachycephalic. The earliest brachycephalic skulls that have been discovered are those found at Mugem in the valley of the Tagus, at Offnet in western Bavaria, and a fossil skull that was excavated at Manilla in the Philippines at a depth of from 7 to 9 feet below the surface. The Philippine skull is small and brachycephalic and shows a marked degree of prognathism; there is no chin prominence in the lower jaw and the basal inner part of the mandible shows pithecoïd characters resembling those of the jaw of Piltdown Man. Judging from these characters, it appears to belong to a pre-negrito race. Unfortunately we do not know the exact period to which this skull belongs; but, as regards the Mugem and Offnet skulls, the former are associated with a culture that is Tardenoisian in type, while those from Offnet appear to be Azilian. These skulls, therefore, must be attributed to the late Palaeolithic

phase and are probably of the late Pleistocene period. Here again, however, the earlier occurrence of long-headed skulls in Europe does not prove that dolichocephaly was the ancestral head form; it merely indicates that the long-headed race was the first to be established in Europe.

The differentiation of the human species into long-headed and broad-headed races must have commenced at a very early stage in Man's history. Until comparatively recently it was thought that the condition of dolichocephaly was unknown among the Anthropoid Apes. Keith (1925), commenting on the skull of *Australopithecus africanus* Dart, stated that "it is a true long-headed Anthropoid—the first so far known." Harris (1927) from a study of a large number of radiographs of the skulls of Anthropoids shows, however, that this belief is far from correct; according to him only two examples of dolichocephaly are known in the monkey *Macacuscus rhesus* and the condition of dolichocephaly is unknown in either an Orang Utan or a Chimpanzee, but that in the case of the Gorilla ten cases of dolichocephaly in all have been recorded and of these no less than eight examples occur in the "Rothschild" collection out a total of fifty, in other words in 16 per cent. Harris is, however, incorrect in his statement regarding the complete absence of dolichocephaly in the Chimpanzee. Zukerman (1928) has quite recently published a paper on the Chimpanzee, in which he gives a large series of measurements of skulls and from these measurements I have calculated the cranial indices and I find that out of a total of 102 examples there are as many as 27, or 26.5 per cent. that are dolichocephalic.

Finding that Harris was wrong in his statement regarding the Chimpanzee, I thought it advisable to see if he was correct about the absence of dolichocephaly in the Orang Utan. Hrdlička (1907) has given measurements of 24 skulls and I have examined all the skulls of this species in the Indian Museum collection as well as a collection of skulls in the Raffles Museum, Singapore, which Dr. Boden Kloss very kindly sent to me. I took the measurements of the length and of the maximum breadth; but with regard to these measurements it must be borne in mind that with increasing age, and especially in the male, great bony crests are developed and that these will give a very greatly increased breadth measurement and in consequence an entirely false cranial index. I, therefore, followed the example of Hrdlička (1907) and took the greatest transverse measurement of the skull immediately above the mastoid crest in the region of the temporo-parietal suture; this measurement will, if anything, underestimate the maximum breadth of the skull and thus tend to give a cephalic index that is too low; but in spite of this I found that in the Indian Museum and Raffles Museum series there was not a single case of dolichocephaly and that the majority of Orang skulls

were hyperbrachycephalic, only three falling within the limits of the mesaticephalic group, while in Hrdlička's series six examples (5 males and 1 female) are mesaticephalic. The actual measurements are given in an appendix in Table 1.

In order to complete the review of the Anthropoids, I then examined all the skulls belonging to the genus *Hylobates* in the Indian Museum. Here again I found the same difficulty, though to a much less marked degree, in determining the maximum breadth of the skull; in adult members of this species there is developed in adult life a small bony ridge that runs backwards and slightly upwards from the posterior end of the zygomatic arch and the greatest breadth of the adult skull lies on this ridge, but this would give a measurement that cannot strictly be compared with the breadth of the skull in the human. I, therefore, took the maximum breadth to be the greatest measurement across the skull in the region of the temporo-parietal suture, as in the case of the Orang. A calculation of the cranial indices from these measurements shows that the skull of the Gibbon, *Hylobates*, is considerably longer than the skull either of the Orang or of the Chimpanzee, and out of a total of 8 adult skulls no less than 3, or 37.5%, are actually dolichocephalic, having indices of 73.2, 74.3 and 75.0 respectively, while a fourth skull had an index of only 75.1. There can thus be no doubt of the occurrence of dolichocephaly in the Gibbon.

Owing to the fragmentary nature of the fossil remains of the extinct Anthropoids such as *Dryopithecus* and *Sivapithecus* we have no knowledge of the head shape, but Gregory (1922) claims that this latter species was hyper-brachycephalic. It, thus, seems clear that among the Anthropoids the primitive head form is that of brachycephaly but that we get an occasional long head among the monkeys and that an appreciable percentage of Gibbons, Chimpanzees and Gorillas show the condition of dolichocephaly, while in contrast to this the Orang is markedly brachycephalic. The differentiation of the skull into the two forms thus begins to make its appearance in the anthropoid stock, the ancestral form being normally brachycephalic and the long form of skull being a later development. I have attempted to show this in the accompanying diagram (Text-fig. 2) in which at the bottom we get the brachycephalic ancestral stock, from which originated the brachycephalic extinct Apes *Dryopithecus* and *Sivapithecus*; then comes the branch that gave rise to the brachycephalic Orang Utan; at a later period there arises the common origin of the other Anthropoids in which the tendency towards a long headed skull increases from the Gorilla to the Gibbon; finally on the left we get such intermediate forms as *Australopithecus* and *Pithecanthropus* and the various races of man in which we find a definite subdivision into long-headed and broad-headed forms.

If the phylogenetic development of the human race indicates, as we have just seen, that the broad head is the original type and that the long head arose as a variation from it, we should be able to find that the same process can be detected in the ontogenetic development of the individual. It is, of course, well known that the general proportions of the body and limbs change enormously during the period that intervenes between

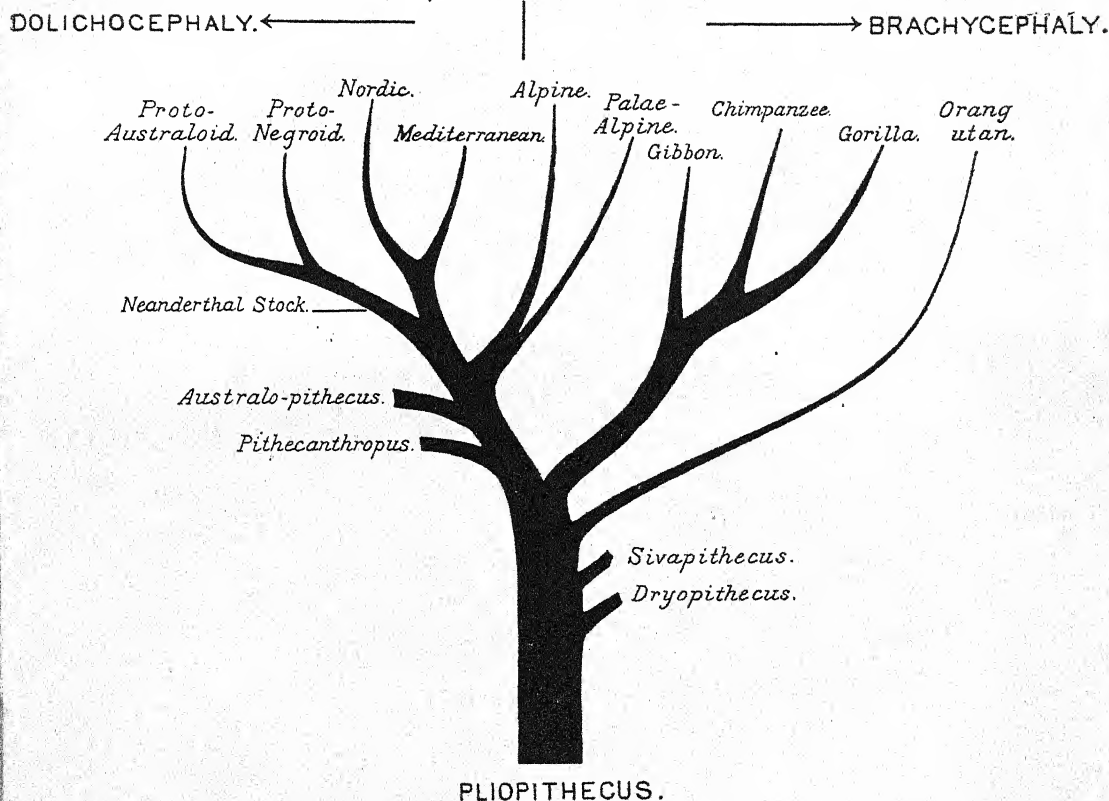


FIG. 2; showing the distribution of brachycephaly and dolichocephaly, in the Primate Stock.

birth and adult life; but it is not so widely recognised that these changes do not take place at the same rate in all races nor is it realised that changes similar to those in the proportions of the larger parts of the body can be detected in the several parts themselves, and that while the proportion of the head to the trunk is changing during growth, so also there is an actual change in the shape of the head owing to the unequal growth of

its length and breadth. Macalister has stated that "the infantile and primitive skull is relatively long and there is a gradual change, phylogenetic (*i.e.*, racial) as well as ontogenetic (*i.e.*, individual) towards brachycephaly." The statement is, however, only partially correct. Wissler (1927) has recently published a paper in which he deals with these body-changes in the inhabitants of Hawaii, and the conclusions that he draws are based on a large number of measurements. He shows that in certain measurements, as for instance, the stature, width of face, width of head, etc., the measurement reaches its maximum at about 30 to 35 years of age and from then on steadily diminishes. These changes are not the result of increased muscular development succeeded by atrophy, but are inherent in the parts themselves. I need not here go into details regarding all the changes to which Wissler calls attention, but I would especially direct your attention to the changes that he has traced in the cephalic index; he has shown that in the particular race with which he was dealing, the average cephalic index at 6 to 10 years of age was 84.7, at 16 to 20 it had dropped to 83.0, between then and an age from 31 to 35 it rose to its maximum of 85.3 and thereafter, steadily diminished throughout the remaining years of life till at an age of 76 to 80 it was only 81.5. Several other authors have called attention to the same changes. Hilden (1925) found as a result of a very careful study of the whole population of the little island of Runo in the eastern Baltic, that the cephalic index gradually fell, with advancing age, from 83.0 in children of 2 to 4 years, to 80.4 in adults. Wissler quoting from the work of Ivanovsky calls attention to the indication, reached by this latter author as the result of measurements carried out on a number of Russians during the great war, that conditions of famine may also produce similar results and cause an alteration of the cephalic index to a lower figure, the head becoming narrower and longer. The work of Boas (1910) has also shown that the cephalic index is not even racially stable in a population that has migrated and that a change of habitat may result in a departure among the offspring from the type of skull that was characteristic of the parents.

If now these changes are going on in the skull-shape at the present day, it seems safe to conclude that they were equally in operation at that remote period of history in which Man was first emerging from the anthropoid stock and this is corroborated by a study of the skulls of anthropoid apes. I have already alluded to the work of Zukerman on the Chimpanzee and from the measurements that he gives it is clear that the cephalic index in the young or sub adult individuals is 80.6, while in the adults the average index is only 76.1. My own measurements of the skulls of the Orang Utan show that we can detect the same changes in that species also; out of a total of 49 skulls

that I examined and measured, 14 were quite young, the 1st molar tooth not yet having been cut, in 11 examples the 1st molar tooth had been cut but not the 3rd, and in 24 the complete dentition was present; in these three groups the average cranial indices were respectively 87.3, 85.8 and 83.2, thus once again showing a clear decrease with advancing age. In the series of measurements given by Hrdlička, he has classed his examples as 'adolescent,' 'adult' and 'adult (ageing)' and the average cephalic indices in these three groups are respectively 83.9, 81.05 and 79.4.

	Young.	Adolescent.	Adult.	Ageing.
Orang Utan (Author)	.. 87.3	85.8	83.2	..
Orang Utan (Hrdlička)	83.9	81.05	79.4
Chimpanzee	.. 80.6	..	76.1	..
Gibbon	.. 80.3	..	76.1	..
Man (Runo)	.. 83.0	..	80.4	..
Man (Hawaii)	.. 84.7	83.0	81.5	..

Table III; showing the decrease of the Cephalic and Cranial Index with advancing age in Man and the Anthropoid Apes.

As Duckworth (1904) has pointed out, owing to the different configuration and especially to the formation of bony ridges in the skulls of adult Anthropoids, the cephalic measurements and in consequence the cephalic index in the Anthropoids is not strictly comparable to those of Man; but the above figures clearly show that the same process is going on in all the forms during the advance of age. A high cephalic index in young children and women, and the tendency to the development of dolichocephaly in the adult and especially in the male, changes that can be equally detected in the Anthropoid Apes and Man, as well as the infrequency of the long-headed condition among the anthropoid apes both fossil and living, to my mind clearly indicates that the original human stock must have been brachycephalic, though a certain proportion of individuals probably exhibited a long head. Hilden (1925) from his examination of the population of the island of Runo further found that when he plotted the cephalic indices of the two sexes separately, they each formed a bi-modal curve. Fisher (1923) working among the cross-bred strains of the Boer-Hottentots of South Africa and the Indian-Whites of North America found that there too a bi-modal curve could be detected in the cephalic indices. The number of Orang Utan skulls that I have been able to examine are too few to give any indication as to whether we can trace the same condition there; but Zukerman's measurements of the skulls of the Chimpanzee clearly reveals its presence in that species; in the females there are two groups having respectively cranial indices of 80.2 and 74.1, while in the males a similar double curve is seen with the two modes at 76.9 and 73.7. An exactly similar bi-modal curve can

be traced in the young, grouping the two sexes together, the two modes occurring at 84.2 and 77.2 (Text-fig. 3).

It thus seems clear that both in the Anthropoid Apes and in the Human race we get identical processes going on, namely a gradual change with age from brachycephaly towards dolichocephaly, and the tendency to the formation of two

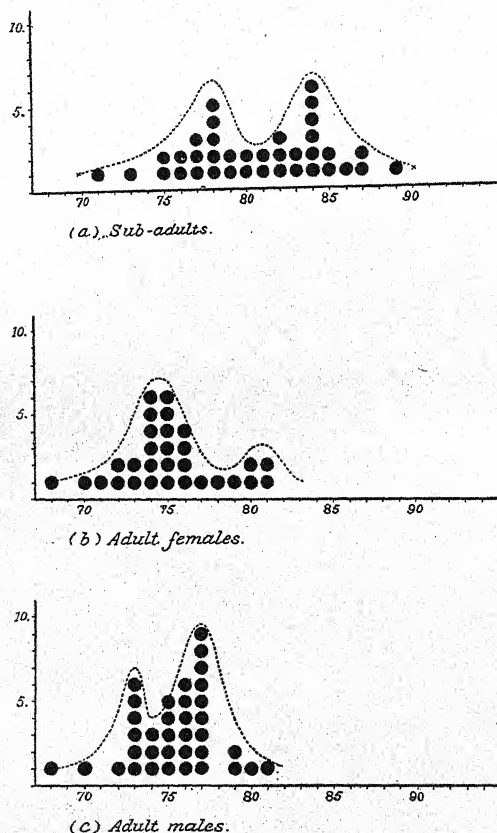


FIG. 3; showing the occurrence of a bi-modal curve in the distribution of the Cranial Index of the Chimpanzee.

groups differing in the proportions of the head, or in other words, a tendency towards dimorphism. It has been argued that the occurrence of these two groups and the formation of a bi-modal curve in the cephalic index of a race or a homogeneous population, such as those of the island of Runo, indicates an origin from two separate ancestral stocks; but if this were so we should have to make the same assumption in

the case of the Chimpanzee, but I doubt whether any zoologist would admit such a possibility.

Such indications as we have been able to glean from the above facts would appear, then, to point to the conclusion that the original ancestor of the human race must have possessed a broad head, so far as the average of all the members of the race is concerned; but that certain individuals probably possessed a long head. We should, therefore, be able to trace a similar condition of affairs in the most primitive races that exist at the present day. I have already alluded to the belief held by some that the most primitive Man is represented by such remains as those of Piltdown and Neanderthal Man. Griffith Taylor (1927) in a recent publication has attempted from a study of the cephalic index and the known distribution of the various races that are living at the present day, to trace the sequence in which these races originated, and he gives the following list:—

- | | |
|----------------|-----------------|
| 1. Neanderthal | 5. Iberian |
| 2. Negrito | 6. Nordic. |
| 3. Australoid | 7. Early Alpine |
| 4. Negroid | 8. Late Alpine. |

Taylor, however, admits that, although he places the Neanderthal race before the Negrito, a study of the distribution of the Negrito peoples shows that they must have been displaced by the migratory pressure exerted by the Neanderthals and that in south-east Asia, at any rate, the Negritos were the first inhabitants. He even suggests that the two races may have originated quite independently in different parts of the globe and that the subsequent migrations of the Neanderthals drove the Negritos into the outlying areas that we find them inhabiting at the present time. Davenport (1925) in an analysis of certain data dealing with the Aboriginal Australians and the Black-White half-breeds, suggests that there was an originally wide-spread race of Neanderthal man, spreading from Europe in the west, and traceable through the Todas of the Nilgiri Hills, the Veddahs of Ceylon and the Talgai skulls of Java to the Aborigines of Australia, and that various modifications or varieties arose from this race by mutations. He suggests that from this single stock one mutation led to the loss of black pigment, as in the Ainus. Another mutation, possibly a reduced endocrine (thyroid?) activity of the pregnant mother might have caused many processes to have stopped before birth, so that the offspring would show many foetal proportions and traits as in the Chinese. Other mutations may have led to the loss of most black and most yellow pigment and the suppression of the supra-orbital prominence, producing the white race; and in this group brachycephaly may have arisen by a mutation, independent of that which produced the Chinese. Finally, a

mutation of quite a different sort may have produced the woolly hair of the Negro and the frizzly hair of the Melanésians. It appears to me, however, that Davenport's view entirely overlooks the fact that the condition of brachycephaly is probably the original ancestral character. The transition from brachycephaly to dolichocephaly begins in the Anthropoid stock but only in certain members of it and those too that are living in a certain area, namely, in the region of Africa and is not seen in the Orang living in Asia; and it only becomes general or, as we may say, the normal condition in certain of the human races. If, therefore, there were any changes, whether mutational or by the process of gradual evolution, these must have been in the direction of dolichocephaly from a brachycephalic stock and not *vice versa*, as I have indicated in Text fig. 2.

Personally, I believe that the first race of the so-called human species must have been the ancestors of the Negrito race or races, for at the present time there appear to be more than one descendant race derived from the original stock. Granted a tendency, such as we have already noted, in certain human races and in the Anthropoids, it is clear that, given suitable conditions of climate, food-supply, etc., one or other type, i.e., either the long-head or the broad-head, will tend to thrive to the extinction of the other type and thus these isolated colonies will be either long-headed or broadheaded. Keith, in a paper recently read before the Royal Anthropological Institute on certain skulls obtained by Sir Aurel Stein in central Asia, has pointed out that the old world or Eurasiatic population can be divided into zones or areas, an eastern and Mongolian region and a western and Caucasoid or Iranian region. The line of demarcation between these two areas, though it is not clean cut, can be traced for thousands of miles. The line starts from the north-west corner of Europe and terminates at the mouth of the Ganges; to the north and east of this line we get the Mongoloid type and to the south and west of it the Caucasoid type, or in other words to the north and east the chief skull form is brachycephalic and to the south and west it is dolichocephalic. In the neighbourhood of the line we get certain races and tribes which are intermediate both physically and geographically; these might be considered to be either hybrids, resulting from the crossing of the two strains, or an undifferentiated type that has not evolved into either form; the conclusion that Keith appears to have reached is that they are the latter and, as the evidence of the skulls shows, this line of demarcation between the two types was in existence as long ago as 2000 years in much the position that it occupies to-day. It thus seems probable that the Mongoloid brachycephalic type has actually been evolved on the north-east side of the above-mentioned line and the Caucasoid, dolichocephalic type, which is said to become pure in the region of the Pamirs and the Oxus valley,

has arisen on the south-west side of the line. - The conclusion thus reached from a study of certain skulls, bears a close resemblance to the views that have been put forward by certain biochemists, who have attempted to trace the relationships of various races and tribes by means of their blood-reactions. The Hirschfelds (1919) found that all human beings can be divided into groups according to the serological reactions of their blood and they concluded that all races can be divided into two groups that arose by evolution or mutation from a common ancestral stock; of these groups, the first in their opinion arose in north or central Europe and the second in the central Asian Plateau, while the present-day differences in different races and nations are due to migration and intermixture of these two original stocks. More recent research has tended to modify this view and to indicate that present conditions are not quite so easily explained. Ottenburg (1925) divides the whole human species into 5 types, but he has also clearly shown that in certain instances the blood reactions undoubtedly indicate the primary origin of the race; thus the Hungarian in Europe and the Gypsies, both of whom have, according to history and tradition, migrated westwards from some oriental country, must be grouped serologically with the southern Chinese in the first case and with the northern Chinese and the Indians in the second; while the Australian Aborigines show a blood affinity to the races of western Europe, where so many of the Neanderthal remains have been excavated and where we know Neanderthal man lived in large numbers, and it is from the Neanderthal race that the Australians are now generally thought to have descended.

I have already called attention to the view that the origin or at least one of the origins of the human race occurred in the region of the Sahara desert, or to be more precise in the region that is now desert but that was at the time this evolution took place an extremely fertile country. It has been pointed out by Peake and Fleure that about the close of the Tertiary period the storm zone, and in consequence the region of profuse rainfall, probably lay about where the Sahara desert is situated to-day, and hence in those times that area must have been an exceedingly fertile one covered with dense forests. Gradually the storm area seems to have shifted further to the north, the rainfall in the Sahara region thus became less, and, as a result, the forests that then spread all over north Africa became replaced by grass-land and with the final cessation of rain were converted into desert. The process is exactly what we have already seen to have taken place in central Asia, and it seems possible, perhaps it would be too strong to say probable, that the similar changes in the two areas were responsible for a two-fold origin of the human race or, zoologically speaking, for the evolution of two forms from a common ancestral stock, the brachycephalic type having evolved in the central Asiatic

region and the dolichocephalic type in the Sahara area. At the time when the human race was first arising from its ancestral Anthropoid form, there were a number of giant Apes widely distributed throughout Europe and Asia; the genus *Dryopithecus* of the middle and late Miocene epochs includes in all seven known species, viz., *Dryopithecus punjabicus* Pilgrim, *D. chinjiensis* Pilgrim, *D. giganteus* Pilgrim from the Siwaliks; *D. darwini* Abel from the Vienna basin in Europe, *D. fontani* Dartet from France and Spain, *D. rhenanus* (Pohlig) from the Swabian Alps and *D. mogharensis* (Fourtau) from Egypt. It thus appears to be possible that the immediate fore-runner of the human race was also widely distributed and that the evolution of the long-headed and broad-headed types may have arisen in different areas from a single ancestral form, and in this connection it is interesting to note that, as we have already seen, the appearance of the long-headed type of skull can be traced in the Chimpanzee and Gorilla, both inhabitants of Central Africa and, therefore, in the vicinity of the region in which at least one of the human strains may have arisen, the line of evolution passing through some such form as the Taungs skull of *Australopithecus* to the normal condition in the African negro and the Mediterranean race. Hooton (1925) has pointed out that, with the exception of *Pithecanthropus* and the Talgai human remains, all the discoveries of fossil man have occurred in areas that are marginal to the great African tropical region, namely, either in Africa or in southern Europe. He comments in his paper on the resemblances between the Neanderthal, African and Australian races and the Gorilla, and between the Mongolian and the Orang, resemblances that have also been pointed out by previous authors, such as Keith, Klaatsch, and others. As he points out "it is perfectly conceivable that an identical environment may tend to foster similar ancestral features in separate stocks of a common origin." He admits that both the regions of the Sahara and of southern and south-eastern Asia fulfil the climatic and palaeontological conditions that were necessary for the evolution of human race and that man may have originated in either area and have later migrated to the other region, but he finally remarks, "at present I am inclined to think that one or more long-headed varieties of man evolved in Africa and one or more broad-headed varieties in Asia" and Keith (1927) holds that at the present day we have three main human types, the Negro, the Chinaman, and the European, that have arisen in the regions where we find them. Can we now trace any factor that may have had an influence in deciding and determining the character of the skull in such different regions. While Griffith Taylor (1927) has recently emphasised the importance of migration in the present distribution of the various types, Keith (1925) has come to the

conclusion that migration has played only the most minor part in shaping the evolution of man. He points out that the more densely populated parts of the world are also the centres of most rapid evolution, and he affirms that we must presume, until we can prove to the contrary, that each racial type has been evolved in that part of the world where we now find it, and that we must apply this rule to extinct and fossil as well as to modern man. It seems to me that both factors must be taken into consideration and that certain facts can be best explained by the first hypothesis and others by the second. We have already seen that the two head types that we are considering can largely be separated into eastern and western groups and a recent paper by Mahalanobis (1928) has called attention to the fact that within the eastern group we can trace a distinct geographical variation, and, as he remarks, "the smaller the distance between any two regions, the greater is the resemblance between the inhabitants of these two regions, or the greater the distance between any two regions the greater is the divergence between the inhabitants of those two regions." So much then for the horizontal distribution but there is another possible line of separation along which we can discriminate between the various classes of the population and that is the altitudinal distribution, or the height above sea-level, at which the two skull-types are to be found. There can be little doubt that at the present day the broad-head type is associated with a high altitude. This is particularly clearly seen if we study the distribution of the two types in Europe; but the same holds good in other parts of the world and it seems clear that the brachycephalic type is directly associated with a high altitude, whereas the dolichocephalic type is connected with a low-lying country. Peake and Fleure (1927) have pointed out that "the Alpine zone proper, in Switzerland and the central Massif of France, shows as one of its most characteristic types a man with broad round head without any striking development of nose or profile and with a rather short stature and thick-set build," and, a little later, they remark that the zone of high land extending from the Pyrenees, through the Alps and the Carpathian Mountains, the Balkan Peninsula, Asia Minor, Armenia, the Pamirs and onwards to Manchuria seems to be largely a belt of broad heads, while broad heads are also characteristic of the highland zones of America. In Text-fig. 4 I have shown the areas of the globe that have an altitude of 3000 feet or over and of the population in which 50% or more of the individuals are brachycephalic: much of the data on which this map is based is derived from Dixon (1923). The agreement, I think must be admitted, is a close one and it would probably be closer still, if we took the altitude as 2000 feet. Taylor (1927 and

1928) has ably discussed the zonal distribution of the long-heads and the broad-heads and, to account for the present

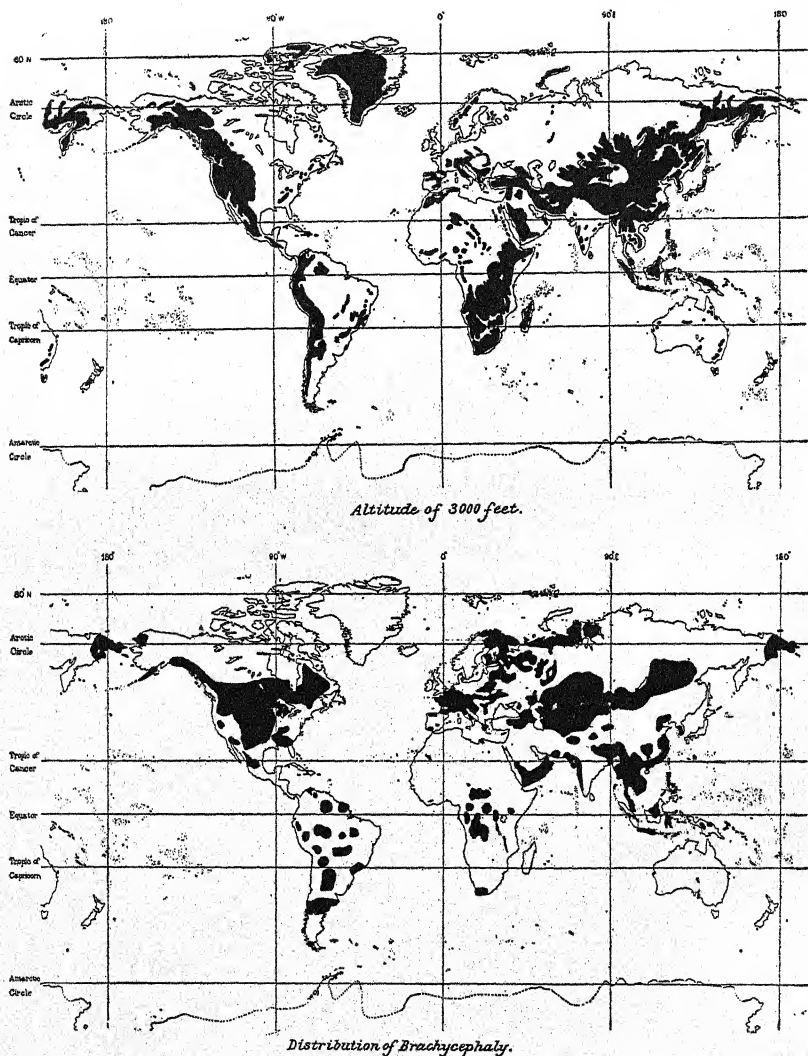


FIG. 4; showing (above) the regions of the globe having an altitude of 3000 feet or more above sea-level and (below) the areas in which the population consists of 50% or more of broad-heads.

day distribution, he postulates a world-wide migration of a later-developed broad-headed race that has displaced the older long headed races; as he points out "there is a belt of narrow

headed races occupying Africa, India, and Australia. They have been thrust away from the Behring corridor into the Yenesei valley and Japan. In America they are found only in the extreme east in the Hudson Bay region and in Brazil." Certainly this hypothesis appears at first sight to present a reasonable explanation of the broad outlines of present-day distribution; but it overlooks the fact that many details of distribution cannot be explained on the hypothesis of an early origin of the long-headed races and later origin of the broad-heads, these latter pushing the long heads into the remote regions of the globe, for it entirely ignores the distribution of the broad-headed Negritos, which, if their present day distribution is to be explained on the grounds of migration, must have been the first and earliest type and they must have been pushed by the later long-heads into the remote areas of South Africa, India, the Andamans and the Philippines, and, possibly, Tasmania. It ignores the generally accepted view that, when primitive man migrated, he did so along the river valleys and across the plains; primitive man can never have migrated along the great mountain ranges at heights exceeding 10,000 feet in altitude. The line of the great Alpine-Himalayan mountain range in Europe and Asia or the Rocky mountains and Andes in America can never have been the line of migration along which the broad heads moved, pushing the long heads down into the fertile and more low-lying country. The natural sequence of migration must have been the exact opposite, and, if the present day distribution of the long-heads and broad-heads be the result of migration, either voluntary or enforced, then either it is the long-heads that have pushed the broad-heads away from the fertile plains into the inhospitable high-altitude regions, the intervening areas being occupied by mixed races, or else there is some physiological connection between life at a high altitude and the possession of a broad head, or, in other words, the broad head has been evolved as a result of living in mountainous regions and the long-head in low-lying countries.

This difference in altitude is one of the most marked contrasts between the two areas, namely the region of the Sahara and the central area of Asia, in one or possibly both of which the human race appears to have evolved. The region of the central Asiatic Plateau is one of the highest regions of the globe, while the Sahara is at or but little above sea-level. The fact that we can still trace a distinct geographical distribution and separation of the long-heads and the broad-heads, the brachycephals still associated with high altitudes and the dolichocephals with the plains, clearly indicates that the causative agent that first started the dimorphic tendency in the Anthropoid Apes, and later caused this tendency to become so marked as to produce two distinct types in Man, must

still be active, though migrations may have tended to blur the hard and fast lines between the distributional areas of the two types.

The researches of Hagen (1906), Bryn (1920), Fischer (1923) and others have shown that in crosses between the two types the condition of brachycephaly is dominant over dolichocephaly. After the lapse of time that has intervened since the evolution of the two types of skull, we should have expected to find that the vast bulk of the world's population would have been broad-headed; and since this is not so, we must conclude that there is some factor that is tending to preserve the dolichocephalic type. If, as I have suggested, this factor is connected with a low altitude, we should expect to find, as we do, that the brachycephalic type, having originated in and being perpetuated by life at a high altitude would by its dominance over the dolichocephalic type tend to spread beyond the strict limits of this altitudinal distribution and that the races nearer to the high regions of the earth would tend towards the brachycephalic type of skull, whereas those further away would tend towards the dolichocephalic type. We should thus get a series of zones exactly similar to those that Griffith Taylor has called attention to, with a brachycephalic central area and a dolichocephalic marginal zone.

What then are the factors that may have had this effect on the skull resulting in the production of two distinct types? It is possible that one factor in the production of the broad-head was the increase in the brain mass and the consequent necessary enlargement of the cranium. The size of the brain increases enormously as we pass from the Anthropoids to Man but I do not believe that the shape of the skull is dependant on the bulk of the brain, and in many of the prehistoric races of Man the size of the brain was considerably larger than it is in even the most civilised, and, presumably the most intelligent, races of the present day. Nor is the difference between the brachycephalic and dolichocephalic types due to any differential development of certain areas of the brain cortex or the different lobes. It is due to some inherent character of the body that causes the bones of the skull so to adjust their curvature that the enclosed brain cavity is either ovoidal or nearly spherical or some intermediate shape, as we pass from the various degrees of dolichocephaly through mesaticephaly to the extremes of brachycephaly. Now it is well known that the least surface area encloses the greatest mass when the shape of the object is spherical; a brachycephalic skull, therefore, will contain the brain with the least possible expenditure of calcium salts and the smallest amount of bone-formation, whereas the amount of bone required to enclose the same brain in a dolichocephalic skull would be considerably greater. It is thus possible that in the brachyce-

phalic skull we have evidence of an attempt on the part of the body to conserve the amount of bone-forming material and to enclose the brain in its protecting box with the least possible expenditure of calcium salts. If this were the case, we ought to find that the condition of brachycephaly was associated with a similar tendency towards the reduction of bone-formation in other parts of the body and especially in the long bones of the limbs, the result of which would be to cause a diminution in the stature; and in the main this is actually the case. In this connection it is interesting to note that the Anthropological study of the American Army that was carried out during the great war of 1914-1918 showed that it was the men of short stature that were most prone to defective teeth. We thus get the association of short stature, defective teeth and the brachycephalic skull; and it would seem justifiable to conclude that the controlling factor in the production of these three characters is either a deficiency of calcium salts in the diet, or in the extent to which the body can utilise the calcium salts with which it is supplied, resulting in a lowered calcium metabolism and a reduction in the amount that is deposited or built up into the skeletal tissues.

We have already seen that the evolution of man from the Anthropoid stock was attained during and was in all probability the result of a change of climate from a moist, forest region to an open grassy upland or plain; equally associated with the change of climate and habitat must have come a change of food and a consequent change in the chemical composition of the food-material. Foremost in importance from the developmental point of view in the food-materials are the Vitamines, those strange and only recently discovered elements that seem to regulate the growth and development of the body; and a change in the amount and nature of these ingredients of the diet may have been one of the most important factors in the evolution of *Homo sapiens*. At the present day we are acquainted with six of these vitamines; with regard to five of them the chemical nature is still obscure, but in the case of the sixth, vitamine D or the Antirachitic vitamine, we know that it may be produced from a fatty substance, known to the chemist as Ergosterol, by the action of sunlight and that, further, ergosterol appears to be an ingredient of all fats. At least two of the vitamines seem to be concerned in the regulation of the calcium metabolism and the formation of the skeleton. Fisher (1923) has shown that a deficiency in the diet of Vitamine A can in 5-8 weeks produce changes in the size and shape of the skull of rats. Vitamine D, however, appears to be the Vitamine that is pre-eminently necessary in the diet for the proper building up of the bones and teeth, and in climates that are by nature comparatively sunless there is a likelihood that this factor will be deficient. The first symptom of a deficiency in

the quantity of this vitamine in the diet is a corresponding deficiency in the amount of calcium salts in the teeth and a consequent tendency to dental caries, and the magnificent teeth possessed by dwellers in the tropics is directly traceable to this cause.

The sun's rays falling on the skin can produce from the fats contained in the sebaceous glands sufficient Vitamine D to serve the functions of the body or by a similar action on cattle can increase the Vitamine D content of the milk and so act in an indirect manner on the human being who partakes of milk in his diet. At the time when Man was first evolving from his Anthropoid ancestor he had not yet learned to domesticate cattle, so that this latter or indirect action of the sun need not be considered. In the case, however, of the former method, namely, the direct effect of the sun's action on the human being, the meteorological conditions prevailing in the Sahara and the central Asiatic Plateau, the two areas in which it seems possible that Man became evolved, must have been very different. In the plains region at or near sea-level, the actual amount of sunlight during the year must have been considerably greater than in a high altitude, especially in a high altitude during the Glacial epochs, since the increased cold must have resulted in the mountains and hills being to a very large extent shrouded in cloud and mist. Again, in such a plains region the air temperature must have been considerably higher than at an altitude of 3000 feet or over and, therefore, man's covering, which in the early days of this evolution was hair, but at a somewhat later date was supplemented by skins, etc., must have been considerably thicker and of greater amount in the high regions. In both these cases the effect will be a shielding of the skin from the direct action of the sun's rays and a consequent deficiency in the production of Vitamine D in the body. This, in turn, will necessitate a conservation and a sparing use of calcium salts in the metabolism of the body, that, while not sufficiently marked to produce changes that we might consider pathological, yet when continued over a number of successive generations may have been able to modify the metabolism of the body and cause a lowering or diminution of the bone-forming process, and so ultimately give rise to a race in which a broad head was combined with a diminished stature.

The evidence that we have been considering seems to indicate the possibility that the human race has either had a double origin, a brachycephalic race arising in the central Asiatic Plateau and a dolichocephalic race in the region of the Sahara, or that an original single ancestral stock early became differentiated into two such races. The proximity of India to Central Asia would lead us to expect that the earliest inhabitants of this country would be brachycephalic; but in this connection there are certain points in the geographical and

geological history of this country that we must bear in mind. At the close of the Cretaceous Period and the commencement of the Tertiary Epoch India was an island, completely cut off from the rest of Asia by the Tethys sea that ran from east to west across the northern coast of Peninsular India in about the position where to-day we get the great Gangetic valley. Whether man originated in the Sahara or in Central Asia or both, it is clear that his immediate precursor, that missing link, half man half ape, could not at that time have penetrated into this country, though he might have already migrated to other regions. Gradually, however, this intervening sea became obliterated. In the middle of the Tertiary epoch the Himalayas rose steadily and these upheavals, as has been pointed out by Pascoe (1919), "during the Nummulitic epoch drove the old Cretaceous sea westwards. Tibet and the whole of the Himalayas (with the exception of the Ladak Valley) becoming dry land. They, however, assisted in producing a depression along the base of the continuous series of mountain arcs, forming a gulf in which a constant struggle took place between the deposition of silt tending to fill up the gulf and the general subsidence tending to deepen it." With successive changes the gulf became more and more reduced in size but was continued to the east by a river, to which the name Indo-brahm has been given; still later the gulf became a series of lagoons or lakes, and, this stage proceeding yet further, there was formed in Pliocene times a large river that then flowed right across the whole width of northern India from east to west and opened into the Arabian Sea, where the Indus opens at the present day.

The first connection between India and the rest of continental Asia in the middle of the Tertiary epoch must, then, have been on the east and it was from the east that at about this period the vertebrate fauna of India poured into the Himalayan region and the country to the south; and probably with or following on the inroad of the vertebrates, came Man and those closely related forms *Dryopithecus* and *Sivapithecus*. All through the later part of the Tertiary epoch and in the early Pleistocene the connection between India and Asia was increasing but at the same time the great mountain range of the Himalayas was rising higher and higher and this, combined with the effect of the Glacial period in Pleistocene times, probably proved a sufficient barrier to the transmigration across the range of the northern races.

The first immigrants, coming as they almost certainly did, from the north-east, should, if our previous conclusions have been correct, belong to that division of the human race that probably lay then, as it does to-day, in the region of central Asia and in consequence must have been brachycephalic. We have already noted that the earliest race that shows a broad head and probably the earliest race to appear in Asia is the

Negrito stock, and both Hutton (1927) and Guha (1928) have recently called attention to the fact that we can still find traces of a Negrito strain in certain of the more primitive tribes such as the Nagas and the primitive tribes of Cochin.

The next invasion that appears to have taken place also seems to have come from the north-east, and this second invasion was in all probability part of a big movement that has left traces of itself in India, in the Naga Hills and as far a-field as Melanesia; and has resulted in our still finding traces, such as the Megalithic culture of certain regions of India, that exhibit a distinct connection with the culture of the Melanesians. A third invasion soon followed but on this occasion the line of penetration seems, in all probability, to have been not on the north-east but on the north-west. The gradual changes that had been going on in the physical features of this country, combined with either the close, or at least a temporary withdrawal, of the Glacial conditions, permitted an immigration into India of the Proto-Australoid descendants of Neanderthal Man and thus give rise to the Pre-dravidian tribes that we still find scattered throughout the more inaccessible parts of the country. Still later came an invasion of Alpines from the region of central Asia and on this occasion also the invasion came from the north-west; and still later again the invasion of the Mediterranean Race through the north-west route: and one or other or possibly both of these last migrations seems to have been connected with the establishment in the Indus Valley of the civilisation that is now being investigated in Mohenjo-daro and Harappa.

So much then for the past; and now for a few moments I propose to turn to the future. Unless we believe that Man has reached the end of his evolution and that the future holds no possibility of progress, and I hope that there is no-one present who would accept such a view, we must admit that man is still changing. It is, therefore, of the greatest importance that we should keep a record of what is going on, not only in the race, but also in the individual, for it is only by observations on large numbers of individuals that we can get evidence of what is happening in the race. It is now thoroughly well established that throughout the whole course of life the individual is continually altering. I have already referred to the changes that take place in the cephalic index with advancing age and exactly similar changes can be detected in many, if not in all, the other measurements and indices of the body. But these changes do not apparently occur at exactly the same age in the development of different races; they appear to be early in some and late in others. In order, therefore, to be able to compare with the greatest degree of accuracy, measurements taken on different races and tribes, it is essential that we should know the ages of the individuals and their curves of growth. In

the case of India but little work of this nature has been attempted, though the subject is one of great importance. With changing habits and customs there will, in all probability, be a change in the development of the individual and, ultimately, in the development of the race. What, for example, is the result of education and the consequently necessary sedentary type of life at the most important period of an individual's existence, namely, the period from the onset of puberty to the attainment of the adult stage, a time when nature is putting the finishing touches to her previous work, when the important molar teeth are being cut, when the bones are becoming consolidated, epiphyses joined to diaphysis in the long bones and the tips of the spinous and transverse processes joined to the bodies of the vertebrae in the back-bone?

It is of the greatest importance that we should keep a record of such changes and I would urge every Educational authority to institute a system by which a record of every student is maintained. In England and other countries we now have Medical Officers from the Department of Health, whose duty it is to inspect the students and to see that they are given proper medical treatment, when such is required. These medical officers may point to the prevalence of certain features such as stunted growth, myopia or defective teeth, etc., all of which observations are of importance to the Anthropologist just as much as to the medical officer; and with a little more time and a few more observations, such as the length and breadth of the head, its maximum circumference, etc., we might gain a very valuable addition to our knowledge regarding the development of the race as a whole, and the more detailed such a record, the more valuable it would be.

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APPENDICES.

No. of Specimen.	Sex.	Max. Length. mm.	Max. Breadth. mm.	Cranial. Index.	REMARKS.
7972	+to	101	88	87.1	Pm 2 uncut.
7492		101	91.5	90.6	M 1 "
3204(3. hhh)		103.5	94.5	91.3	M 1 "
? (30.8.97)		105	92.5	88.1	M 1 "
6659		105	93	88.6	M 1 "
3741 (3y)		104.5	97	92.8	M 1 "
7974		106	91.5	86.3	M 1 "
3 fff		107	91	85.0	M 1 "
1436		108	96	94.0	M 1 cut.
9026		109	96.5	88.5	M 1 uncut.
7325 I.M.		109	94	86.2	M 1 "
I. M. Cat. 3m.		110	90	81.8	M 1 "
8422		112	94	83.9	M 1 cut M 2 uncut.
333		112	98	91.1	M 1 cut.
7226		115	100	87.0	M 1 uncut.
3367; 3u.		115.5	99	85.7	M 1 cut M 2 uncut.
....		118.5	97	81.9	M 1 uncut.
7691		119	98.5	82.8	M 3 cut.
7968		119.5	96	80.7	M 1 "
4 D		123	99	79.7	M 3 "
4147		123	112	91.1	M 3 just cut.
7333		124	96	77.4	M 1 cut M 2 uncut.
3464 (3 C)		125	100	80.0	M 3 cut.
3740 3a		126	113	89.7	M 3 "
8005		126.5	100	79.1	M 3 "
3 tt		126.5	113	89.3	M 3 "
3 qq		127	114	89.8	M 3 "

Table I (a); giving the length, breadth and cranial index of 27 specimens of Orang in the Indian Museum.

♀		Max. Length.	Max. Breadth.	Cranial Index.
Sub-adult	.. 99.0	85.5	86.3	M 1 uncut.	
Adult	.. 110	91	82.7		
"	.. 111	89	80.2		
"	.. 112.0	93.5	83.5		
"	.. 115	93	80.9		
"	.. 115.0	96.0	83.5		
"	.. 115.5	90.0	77.9		
Sub-adult	.. 117.0	99	84.6	M 1 cut M 2 uncut.	
Adult	.. 118.5	96.0	81.0		
"	.. 119	97	81.5		
♂					
Sub-adult	.. 107	94.5	88.4	M 1 and 2 cut M 3 uncut.	
Adult	.. 108	89	82.4		
"	.. 113.0	92	81.4		
Sub-adult	.. 114	97	85.1	M 1 and 2 cut M 3 uncut.	
"	.. 115	103	87.8	M 1 cut M 2 uncut.	
"	.. 117	99	84.6	M 1 cut M 2 uncut.	
Adult	.. 120	100	83.3		
"	.. 120	104	86.7		
"	.. 121	101	83.5		
"	.. 122	101	82.8		
"	.. 122.0	102	83.6		
"	.. 125	100.5	80.4		

Table I (b). Measurements of 22 Orang skulls from the Raffles Museum, Singapore.

♀	—	Max. Length.	Max. Breadth.	Cranial Index.
		118	102	86.4
142183	adolescent	.. 119	94	79.0
142181	near adult	.. 121	97	80.2
142196	adult	.. 121	98	81.0
142199	adult	.. 121	103	85.1
142197	near adult	.. 123	97	78.9
142194	adult	.. 123	102	82.9
142188	adolescent	.. 124	94	75.8
142189	adult (ageing)	.. 126	100	79.4
142198	adult	.. 127	100	78.7
142192	adult	.. 130	112	86.1
142195	adolescent	..		
♂				
		112	91	81.2
142187	adult	.. 112	92	82.1
142193	near adult	.. 112	92	82.1
142170	near adult	.. 112	92	82.1
142190	adult	.. 113	92	81.4
142202	adolescent	.. 113	93	82.3
142169	adult	.. 115	89	77.4
142185	adult	.. 115	98	85.2
142182	adult	.. 117	96	82.0
142186	adult (ageing)	.. 118	95	80.5
142191	adult (ageing)	.. 120	98	81.7
142201	adolescent	..		

Table I (c); giving the length, breadth and cranial index of 22 Orang skulls in the "Abbott" collection (from Hrdlička).

	(Author)		Max. Length.	Max. Breadth.	Cranial Index.
	♂				
V. Bischoff	99	89	90.0
"	102	91	89.2
Selenka	115	98	85.2
"	116	99	85.4
"	116	99	85.4
"	117	102	87.2
"	123	106	86.2
"	126	107	84.9
V. Bischoff	128	115	89.8
	♀				
Schwalbe	101	97	96.0
"	102	95	93.1
Selenka	109	93	85.3
"	111	95	85.5
"	111	97	87.4
"	115	97	84.3
V. Bischoff	120	95	79.2
Selenka	120	102	85.2
	Sub-adult				
Selenka	96	87	90.7
V. Bischoff	98	85	86.7
Selenka	106	91	85.8
Schwalbe	109	97	88.9
Selenka	110	96	87.3
"	113	98	86.7
Herve	128	106	82.8

Table I (d). Measurements of Orang skulls from previous authors.

Hylobates.	Maximum length of Cranium.	Maximum breadth of Cranium.	Cephalic Index.
Sub-adults			
7543	72.5	61.0	84.1
7831	73.0	61.0	83.6
7457	73.5	58.5	79.6
7649	74.0	58.0	78.4
7540	75.0	59.5	79.3
7541	75.0	62.0	82.7
7650	75.5	61.0	80.8
7547	75.0	61.0	80.3
7539	77.0	60.0	77.9
7923	78.0	63.0	80.8
7546	78.5	62.5	79.6
7654	80.0	61.0	76.2
Adults			
7913	81.0	62.0	76.5
7679	81.5	63.0	77.3
7544	82.0	65.0	79.3
7833	82.0	61.5	75.0
7837	83.0	65.0	78.3
7834	83.5	62.0	74.3
7878	84.0	61.5	73.2
7548	88.5	66.5	75.1

Table II; showing the measurements of a series of crania of Hylobates in the Indian Museum.

Section of Anthropology.

Abstracts.

1. A short Account of the Manners and Customs of the Korachas, a Criminal Tribe of Mysore.

L. K. ANANTHA KRISHNA IYER.

2. The Valayans of Pamban.

S. T. MOSES.

Introduction; Origin and Tradition; Title; Habitation; Physical features; Cephalic and other Measurements; Social Status; Occupation; Religion; Customs; Food.

3. Basketry of Assam.

CHITTA RANJAN ROY.

A study of the Morphology; Technique; Design; Form; Shape; Size; Utility and Distribution of the specimens of Baskets, exhibited in the Ethnological Gallery of the Indian Museum, Calcutta. Classification based on Technique is attempted and inter-relations and differences between specimens from different localities are discussed.

4. On a "Drop-door" Fishing Trap used in the Mitkyina District, Upper Burma.

B. CHOPRA.

The Indawgyi Lake is a large stretch of fresh water in the Myitkyina District of Upper Burma and has a very rich Fish fauna. Most of the fishing is done with the help of large fishing enclosures that are set up in the course of the streams connected with the lake, but trapping and netting of fish is also extensively pursued. *Kya-myon* or the 'drop-door' trap, is a cone-shaped basket with a door at the broad end, sliding up and down between a double frame, and with a ramification of strings inside. A bait is tied near the narrow end of the basket behind the strings and the fish in trying to reach it cannot help touching one of the strings, when the door automatically snaps down.

5. A Preliminary Account of the Anthropometry of the Parsis.

B. S. GUHA.

The results of measurements, taken on the Parsis in Bombay, are discussed and comparison made with those of the Guebres (of Zoroastrian faith) of Persia.

6. On some aboriginal Crania from Bihar and Orissa.

PROVASH CHANDRA BASU and CHITTA RANJAN ROY.

(Communicated by Dr. B. S. Guha.)

A comparative study of the 29 Munda, Kol, Santal, Juang, and Oraon Crania in the collection of the Indian Museum, Calcutta. Analy-

sis of the measurements taken according to the International Agreement and the Racial Significance of the results attained are discussed.

7. Anthropological Notes on some Assam Castes.

BHUPENDRA NATH DATTA.

The subject matter of this paper is the comparative anthropological study of some castes of Assam. For this purpose somatic measurements taken on eighty-eight subjects of different Assam castes have been made use of. The subjects of the following castes have been examined :—

1. Kayastha	14 subjects.
2. Kalita	18 "
3. Brahman	12 "
4. Ahom	2 "
5. Koch	4 "
6. Sau	2 "
7. Keot	10 "
8. Rajbansi	12 "
9. Moslem	2 "
10. Cachari	5 "
11. Nath	5 "
12. Mali	2 "

In looking at the curves of the cephalic indices, nasal indices, bi-zygomatic and stature indices, it is to be seen that the subjects are of heterogeneous physical characteristics. Again, by making a biometric analysis of the data of the cephalic and nasal indices it is found that the dolichoid-leptorrhinian type is the biggest element. Next in consideration comes the brachycephal-leptorrhinian element. The third element in the order of succession is the dolichoid-mesorrhinian type.

Though the province of Assam stands nearer to the zone of the East-Asiatic racial group, the brachycephal-mesorrhinian and chamoerrhinian elements are not dominant here.

As regards stature it is found in the curve that more subjects fall within the nomenclature of "below the average" and "average" groups than "above the average" and "tall" groups.

Finally it may be said, that the majority of these subjects have some affinity with the Hindus living outside Assam.

8. The Location of the Nasion on the Living.

B. S. GUHA and PROVASH CHANDRA BASU.

An attempt is made to define the exact position of the Nasion in different races with reference to its distance from the Glabella, as measured on different series of crania in the collection of the Indian Museum.

9. The 'dog-bride' in Santali and Lapcha Folklore and the 'caterpillar-boy' and the 'caterpillar-husband' in Santali and Lhota Naga Folklore.

SARAT CHANDRA MITRA.

The Santals of the Santal-Parganas believe in the existence of human beings who are capable of metamorphosing themselves into dogs and caterpillars. The first of these beliefs is illustrated by a Santal folk-tale in which a human girl transforms herself into the guise of a dog. This

change is discovered by her human husband who burns her dog-skin-guise and she remains a human girl thereafter. A similar story is also current among the Lapchas of Sikkim.

The second belief is illustrated by a Santal folk-tale in which a human boy transforms himself into a caterpillar and is subsequently married by a princess who, discovering the secret of his metamorphosis burns his caterpillar-guise, and so he remains a human boy thereafter. This is paralleled by a similar story which is current among the Lhota Nagas of Naga Hills. The author attributes these similarities to the "Psychic Unity" of these three widely separated peoples.

10. Aetiological Myths. (a) "On a Lushai-Kuki Myth about the Great Horn-Bill." (b) "On a South Indian Myth about the Malabar Pied Horn-bill." (c) "On an Andamanese Myth about the Malayan King-fisher and the Black-capped Purple King-fisher," and (d) "On an ancient Indian Myth about the enmity between the Crows and the Owls."

SARAT CHANDRA MITRA.

In the first instance the Lushai-Kukis of the Assam hills narrate a myth to the effect that, during the great darkness caused by a solar eclipse, their chiefs were transformed into the Great Horn-bill, (*Dichoceros bicornis* (Linn.), whose enormously huge and long beaks represent the bamboo rods which the former used for stirring their boiling rice with.

In the second instance, the author gives the result of his study of the South Indian myth which is to the effect that the Malabar Pied Horn-bill, *anthracoceros coronatus* (Bodd.), was originally a cow-herd boy who, by way of punishment, was metamorphosed by Vishnu into the form of this bird for having refused to supply a drink of water to the sacred cow.

In the third instance, the author discusses an Andamanese myth in which it is narrated that the Malayan King-fisher, '*Alcedo meainiting* Horst., or the Black-capped Purple King-fisher, '*Halcyon pileata* (Bodd.), flew up to heaven, stole fire from a sleeping supernatural being, brought it down to earth and supplied it to the ancestors of the modern Andamanese.

In the fourth instance, the author has dealt with the ancient Indian Myth which explains the origin of the enmity between the Owls and the Crows.

11. Aetiological Myths of the Birhors concerning the pinnate leaves of the Tamarind tree and wild Date-palm.

SARAT CHANDRA MITRA.

The Birhors of Chota Nagpore explain the origin of the pinnate leaves of the Tamarind tree (*Tamarindus indica*) and of the Wild Date-palm (*Phoenix sylvestris*) by inventing the following myth:—After Rama had been exiled by his father Dasaratha he, his wife Sita and his brother Lakshmana went to the forest where they lived in a leaf-hut which was over-shadowed by Tamarind trees and Wild Date-palms which had large and broad leaves in those days. Realising that they had come to the forest for undergoing sufferings and troubles Rama ordered his brother Lakshmana to shoot at the broad leaves of these trees with his bow and arrows. This the latter did and the broad leaves were split up into their present pinnate forms which have remained ever since.

The author thinks that these myths illustrate in a striking manner Rama's filial piety, devotion to truth and love of self-sacrifice.

12. Note on the Birhor Legend about Ravana's abduction of Sita.

SARAT CHANDRA MITRA.

The Birhors are a small Dravidian tribe living in the forests and hills of different parts of Chota Nagpur. They have now taken to cultivation and have settled near Hindu villages. By remaining near their Hindu neighbours, they have adopted many religious ideas of the Hindus and have assimilated many Hindu legends into the body of their own tribal beliefs and traditions. For instance, they have adopted the Hindu legend about Rama, Sita and Lakshmana and have assimilated it thoroughly by giving it a local Dravidian colouring and aboriginal touches, as would appear from the following example.

After Sita had been abducted by Ravana, Rama and Lakshmana went in pursuit of her and her abductor. On the way Rama met a jujube tree, a paddy-bird, and a squirrel and enquired from them the whereabouts of Sita and her abductor. The jujube tree told Rama that it had tried its best to prevent her from being carried by the demon. Thereupon Rama blessed it with tenacious vitality. The paddy-bird expressed its utter unconcern about her whereabouts. Thereupon he punished it by elongating its neck. The squirrel also gave Rama cheering news about Sita. Thereupon he stroked its back with his fingers and thus produced the three marks upon its back.

These and other incidents are not to be found in the orthodox Hindu version of Ravana's abduction of Sita.

The author shows that these incidents occur in two Santali and a Munda folktale and that the Birhors have borrowed them from their folklore and foisted them into their own adaptation of the Hindu legend to make the assimilation complete.

13. The Woman in Ancient Royal Families.

J. C. DE.

The subject is vast and it is desirable to define its scope at the outset. Our study is confined to Northern India between the fourth and tenth centuries A.D., the Gupta age and the period which followed it. The most comprehensive and trustworthy sources of information for given periods are inscriptions. These may be divided into two broad classes, Charters on copper (*tamra-sasanas*) and Eulogies (*Prasastis*) generally engraved on stone. Instances of their being carved on wood and chiselled on iron also occur. They are generally either conveyances in favour of a religious person or corporation, or a record of the achievements of a monarch.

Paucity of material hinders a comprehensive research. Out of a group of twenty-five inscriptions of different dynasties only seven refer to the female members of the royal family. Many of these inscription-writers held very responsible offices, *e.g.*, those of Captains, Generals and Ministers-in-charge of "Peace and War," and they must have been conversant with the principles on which the society and polity of their times were based. Limitation of space was not a consideration with them as the length of many of the inscriptions shows. One, for example, mentions twelve generations of monarchs and contains more than eighty lines. It can also be proved that a sense of superiority or originality did not actuate these inscription-writers. Consequently, one cannot but feel that the princess was regarded as inferior in status to the prince.

Polygamy was common among the princes of the period. The queen being one of many was naturally inferior in status to her counter part in Christian Europe, for example. This practice also gave rise to two distinct classes of Queen-Consorts, the mothers of the heirs-apparent, who are sometimes mentioned in inscriptions, and others.

The status which the princess enjoyed was not her own but was derived from that of a male member of the royal household. The Regent of a kingdom issuing charters on her own authority was known officially as the "mother of the heir apparent." The woman followed her husband to the funeral pyre, and at least one instance exists in which this was regarded as a highly meritorious act.

Though complete seclusion of women did not certainly exist, the words used to denote female establishments show a distinct tendency towards the separation of these from the other portions of the palaces.

The status of women though inferior to that of man was not low and despicable. Woman had even the military profession open to her.

The glory of the semi-divine king born in a family which claimed as ancestors pious sages and even gods, was reflected on the princess in two ways. As a consort she was frequently referred to as *devi* (literally goddess) even by the king himself, and as a daughter she claimed semi-divine descent. Instances are not rare where the story of such high birth is prominently brought out in inscriptions.

The king in many cases deemed that the status of himself and his dynasty had been raised by marriage with particular princesses.

Powers which woman exercised in the State were not negligible. Temples were built, villages were granted by her for educational purposes and numerous elephants, horses, large sums of money and stores of grain were at her disposal. When the king was a minor, the Queen-Mother could carry on the government of the State. The king and others regarded her with great respect and affection.

Gifts of money and grants of land were generally "made out of devotion" to their mothers by princes. It was the Empress-Mother whom Skandagupta first of all acquainted with news of his glorious victory. The existence of Queen-Mothers also proves that burning of the royal woman on the funeral pyre of her husband was not widespread.

14. An Analysis of the Cult of Jagannath.

HARAN CHANDRA CHAKLADAR.

Various elements are recognisable in the Cult of Jagannath at Puri. Elements borrowed from primitive tribes, the Sabaras, Juangs and others. Buddhist elements absorbed during the wide prevalence of Buddhism in Orissa as shown in Buddhist literature and numerous Buddhist monuments recently brought to light. A Jain Tirthankara image also receives worship in the temple of Jagannath. Brahmanic elements were introduced at different periods—changes in worship introduced by Ramanuja and Srichaitanya.

15. A short Account of Religious Prostitution.

L. K. ANANTHA KRISHNA IYER.

A single act of prostitution in honour of the deity. Permanent religious prostitution, its origin, development and wide distribution. Permanent Temple prostitution in India and outside India. Reasons for recent abolition. Ethnological significance. Conclusion.

16. Note on the *Kath Deota* worshipped by the Hindu boatmen of Patna.

SARAT CHANDRA MITRA.

The author describes the cult of *Kath Deota*, the existence of which he discovered at Patna on the 8th October, 1927. *Kath Deota* or "the

Godling of the Wooden Block" is a deity worshipped by the Hindu boatmen of Patna. The symbol of the godling is a block of wood roughly carved into the semblance of a human face. The specimen, which he examined at Patna, had crude representations of eyes and the mouth carved thereon. It is affixed to the fore-end of every boat. These boatmen say that the "*jīu*", that is to say, the "life" or "spirit" of the boat lives in the symbol or image and that it makes the boat move about on the surface of the waters of the river. The author is inclined to think that it ensures the safety of the boat and of the passengers during the voyages that she makes. In short, "the Godling of the Wooden Block" acts as a mascot or luck-bringer. It is worshipped by the boatmen on the festival-days with the performance of sacrificial rites, and offerings of *laddus* or sugar-balls are made to it.

17. Note on the Goddessling *Maharani* worshipped by the Bhuiyas of the Hazaribagh District in Chota Nagpur.

SARAT CHANDRA MITRA.

The Bhuiyas are a Dravidian tribe who have now been Hinduized. They have now been given brevet rank and are regarded as a water-giving caste. They inhabit the Hazaribagh and Ranchi Districts in Chota Nagpur. They believe in a host of communal ghosts and spirits who have ill-defined functions, and a capacity for mischief and malevolence, and must be appeased by offerings of goats and fowls.

Included in the above-mentioned host of ghosts and spirits who are worshipped by the Bhuiyas of the Hazaribagh District in Chota Nagpur is an invisible and incorporeal spirit of goddessling named *Maharani* or "the Great Queen." She is otherwise designated as "the Devi" or "the Goddessling."

The author describes and discusses an instance of the cult of the aforementioned goddessling *Maharani* which he discovered at Hazaribagh on the 27th October, 1927. The Bhuiyas pray to this goddessling so that she may fulfil their heart's desires and grant them recovery from illness and whenever they are sick. Whenever her deityship grants the boons for which they pray, they set up bamboo-poles bearing white cloth-bannerets on their tops by way of thanksgiving to her. No images are made of this goddessling. Instead of being a malevolent being, she is a benevolent deity who confers benefits on her worshippers.

18. A note on primitive religions in the Ranchi District in Chota Nagpur.

SARAT CHANDRA MITRA.

European anthropologists, notably Sir Herbert Risley and Mr. Edward Clodd, are of opinion that the root-idea which underlies the religion of the primitive and aboriginal tribes of Chota Nagpur is that of some vague and indefinite power which is not a person at all in any sense of the word.

The author describes his observations of two village-shrines which he made in the Ranchi District on the 25th December, 1927. As the result of these observations and enquiries, he is of opinion that the supposed indefinite something which the jungle and primitive tribes of the Ranchi District in Chota Nagpur fear and attempt to propitiate is a corporeal being or person bearing some sort of similarity to Hindu gods and goddesses. For this reason, he says that the dictum of Sir Herbert Risley and Mr. Edward Clodd to the effect that "the indefinite something which the animists of Chota Nagpur fear and propitiate is not a person at all" will have to be revised.

19. Sex and Sex Control in Primitive Society.

D. N. MAJUMDAR.

After a discussion of the theories relating to the evolution of sex consciousness in primitive society, the author cites instances of sex control exercised by the Hos, an aboriginal tribe of the Mundari ethnic type. The sex control exercised by the Hos is manifest in a way which leads us to conclude that within this tribe at least society takes an active part to remedy any breach of the social code and the violation is generally avenged by society and not by the parties concerned. The first case cited in the paper gives an idea of an automatic response to customary observance in savage society; the consciousness of the *mana* or mystic force, call it moral or social, concealed in the tabu, worked its vengeance and the young man could not stand the horror occasioned by the violation of the tabu. In the second case the *mana* lost innate force and it was left to the society to uphold the cause of the violated *mana* by social prescriptions and code of conduct. But the horror of the breach manifested itself here also in the blood of the sacrificed fowl and restoration to the tribal form was ceremonially observed by the offender and then the tribesmen drinking the rice-beer to which a few drops of blood have been added.

20. Witch and Witchcraft in Primitive Society.

D. N. MAJUMDAR.

In this paper the author gives a first-hand account of the indigenous beliefs in witches and witchcraft in primitive societies with which he came in contact during an ethnographic tour in Chota Nagpur and parts of the Mirzapur District, where even to-day the aboriginal life is found at its lowest ebb. The influence of witches and sorcerers on the everyday life of primitive man has always been over-estimated and the author tries to interpret this aspect of primitive life by analysing the beliefs of some of the interesting tribes of whom he claims first-hand knowledge. An account of a *deoghariya* presided over by a *bhagat* or diviner is given which gives an idea of the importance of witchcraft on savage life. The *deoghariya* is situated in one of the less known mouzas of pergunah Dudhi, District Mirzapur and is an institution of great significance to tribal life.

21. Jain Kurumbers; a sketch of their life and habits.

M. D. RAGHAVAN.

22. The Kalari and the Angam; their co-relation.

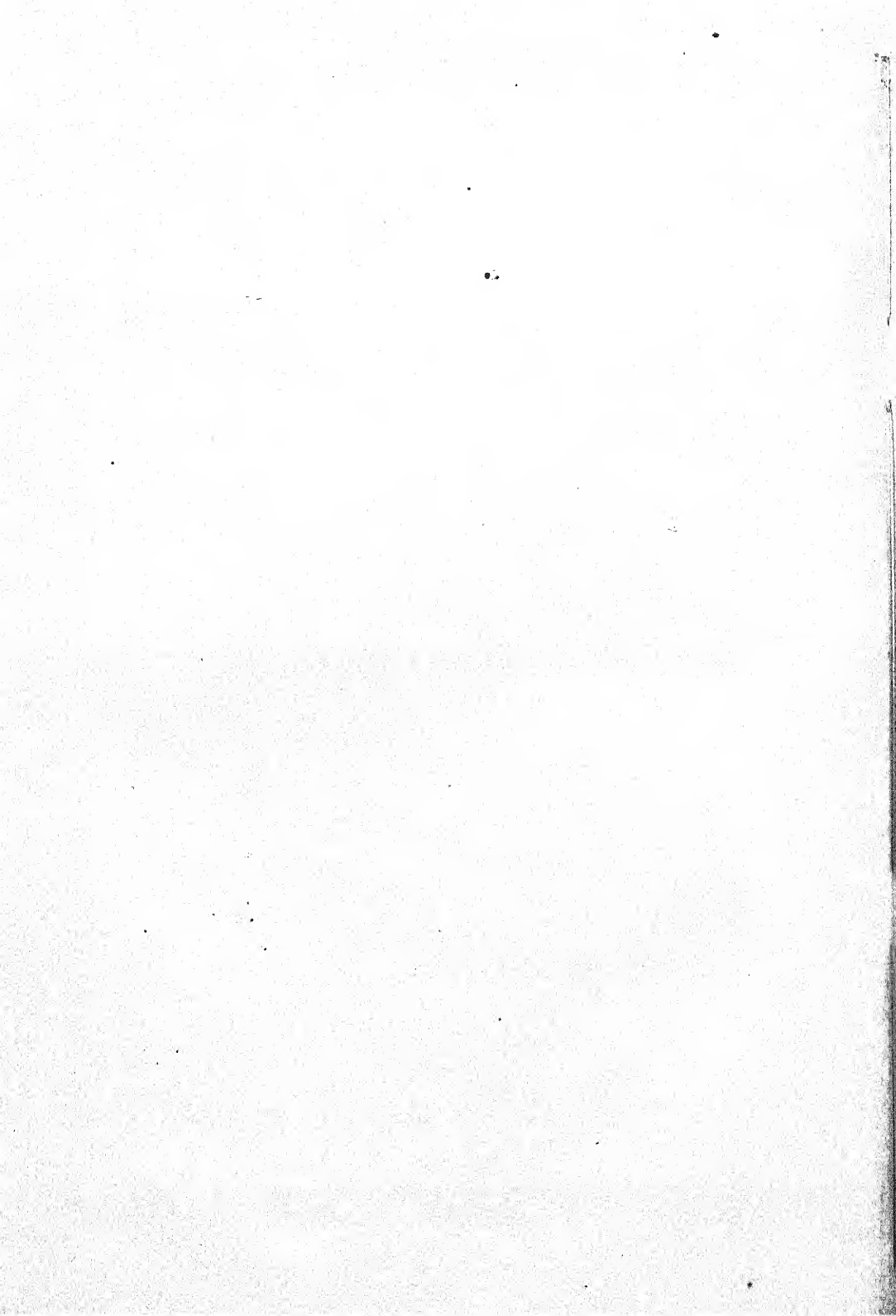
M. D. RAGHAVAN.

23. Talikettha Kalyānam.

M. D. RAGHAVAN.

24. Disease, Death and Funeral of the Wild Kharias of Dhalbhum.

TARAK CHANDRA DAS.



Section of Psychology.

President.—PROF. M. V. GOPALASWAMI, B.Sc., Ph.D.

Presidential Address.

THE PSYCHO-GALVANIC REFLEX AND ITS APPLICATION TO CRIME DETECTION.

I have much pleasure in welcoming you to this session of the Psychology Section. While I deeply appreciate the honour in being asked to preside over the Section, I have accepted the invitation with considerable hesitation. The choice of a suitable subject for address has been a most difficult one for me, on account of my constitutional inability to speak to you as befits the occasion on a topic of general interest, such as the presentation of a conspective view of the modern trends in Psychology. You will pardon me, therefore, if I take this opportunity to describe to you in more detail than was found possible last year, my experiments regarding the psycho-galvanic reflex as an indicator of consciousness of guilt, a subject which has been claiming my attention, almost exclusively, for some years past.

I shall first give a short account of the P.G.R. phenomenon in general and then proceed to describe the Mysore experiments regarding its application to crime detection.

THE PSYCHO-GALVANIC REFLEX.

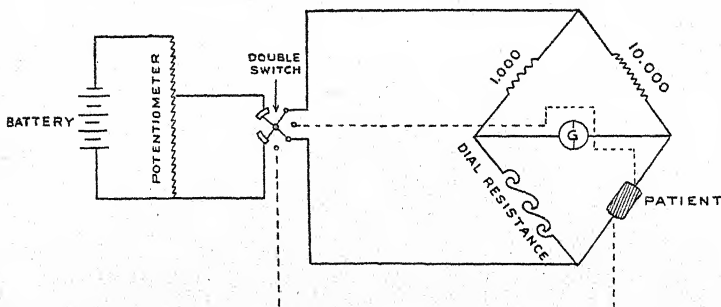
The Psycho-galvanic reflex might be briefly defined as an abrupt variation in the electrical behaviour of the human skin resulting from a mental excitation. The variation is in the direction of a fall of resistance in the body of the patient, where the patient is balanced on a Wheatstone Bridge arrangement. "The variation in the electrical conductivity of the skin is due to a diminution of the counter E.M.F. of polarisation at the points of skin contact as a result of increasing secretion of sweat at these points."

Nearly 40 years back Charles Féré reported that when a patient, a galvanometer, and a low voltage battery (2 to 4 volts), are put in series, an unmistakable deflection occurs in the galvanometer every time the patient is emotionally excited. In 1888, Tarchanoff also observed a similar phenomenon. He noted that the galvanic deflections occurred even when the battery was not included in the circuit, but the deflections were as a rule less marked than in the previous case. From that time to the present day a series of technical improvements in the measurement of the reflex have been effected chiefly through the

efforts of Jung, Waller, Prideaux, Whateley Smith, and Wechsler, culminating in the Psychotacho-gram of Godefroy. We need not pause here to consider these improvements in detail. Below a short account of two of the latest methods, *viz.*, those of Wechsler and of Godefroy is given.

A convenient measure of the psycho-galvanic reflex might be obtained by the following arrangement of apparatus after Wechsler:—

DIAGRAM OF CONNECTIONS.



..... Circuit with patient in series.

————— Circuit with patient in Wheatstone Bridge.

A small source of current (10 to 12 volts) is connected with a potentiometer. From the potentiometer the current is led off through a double-pole switch to either of two circuits. In the first circuit the patient, a D'Arsonval galvanometer, and the battery are connected in simple series. In the second, the subject is so connected as to constitute the unknown arm of a Wheatstone Bridge, of which the other arms are constants of 10,000 ohms and 1,000 ohms, and variable dial resistance with a range of 1,000 to 200,000 ohms. A shunt permits the reduction of the sensitivity of the galvanometer to $\frac{1}{2}$, $\frac{1}{4}$, etc., up to $\frac{1}{100}$, as desired.

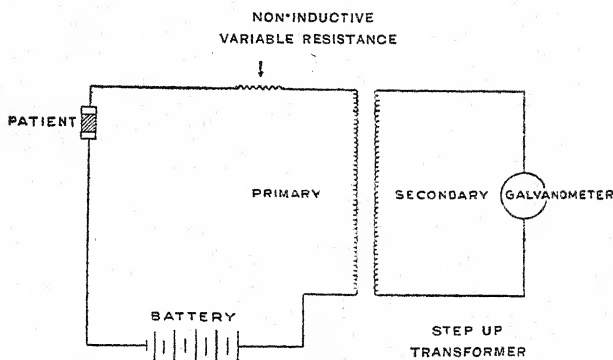
The electrodes consist of copper plates lined with thick wool soaked in concentrated solution of common salt. Suitable springs are attached on both sides of the electrodes so as to keep the pressure on the surfaces of contact constant. After connecting the electrodes to the patient, the switch is turned on to circuit I, and the potentiometer adjusted until the intensity of current necessary to obtain a given magnitude of deflections, is obtained. While doing this the galvanometer is shunted to its lowest possible sensitivity. Next, the switch is turned on circuit II and the patient's initial resistance found by the manipulation of the calibrated resistance box. The instrument is now ready to register the emotive reaction of the patient for any given stimulus. The galvanic deflections might be

recorded photographically or may be read off by the experimenter.

We might also note here the method of Psycho-tacho-gram advocated by Dr. Godefroy of Amsterdam, which is in some respects even superior to the one considered above.

DIAGRAM OF CONNECTIONS OF PSYCHO-TACHO-GRAM.

(After Godefroy.)



The novel feature in the tachographical method consists in putting the patient in circuit with the primary coil of a transformer, while the secondary is connected directly with a Moll's Moving Coil Galvanometer. A non-inductive variable resistance is introduced into the primary circuit so as to prevent any shock to the patient when switching off the circuit. The advantages of the new method are:—

- (1) the Galvanometric deflections become proportionately greater the more *rapid* the changes in the intensity of current in the primary coil;
- (2) after each deflection the galvanometer returns to the zero point thus making possible direct comparisons of successive excursions;
- (3) the tachogram measures only the relative variations in the intensity of the current whatever value the primary current may have initially; and
- (4) the shape of the curve of tachogram is often very significant, apart merely from the magnitude of the reflex.

In the literature of the P.G.R. there is much that is controversial; in the following account of the phenomenon, I propose to confine myself to what is generally conceded by most experimenters.

1. The P.G.R. measures the *intensity* of 'emotion' irrespective of its quality. The reflex by itself gives no indication as

to whether the emotion aroused is say, one of *fear, anger* or *love*. Nor can it show whether the experience is a pleasurable one or of an unpleasant nature. The quality of the emotion could only be guessed from the nature of the stimuli and the external behaviour of the patient.

2. The P.G.R. is only a *rough* measure of the emotional response of the patient, for it takes into account only that portion of the emotional response of the patient, which expresses itself in the sweat glandular changes; also there are individual differences in the reactivity of the skin of different patients. Wechsler has reported correlation coefficients of 0.59 and 0.67 between the magnitude of galvanic deflections and the introspective ratings of patients regarding the degree of emotion they experienced. This correlation might be considered to be rather high, considering the inexperience of the patients in introspection, and the fact that feelings which are sub-conscious also produce a well marked reflex. Further, introspective ratings are liable to be affected by conventional standards regarding how a patient ought to feel in a given situation.

3. The reflex usually has a *latent time* of two to three seconds. It is often possible to distinguish a genuine reflex, from a galvanic deflection produced by disturbances in the points of contact, by the absence of latent time in the latter.

4. The reflex is more marked in regions of the skin which are rich in sweat glands.

5. The reflex is subject to *fatigue*; i.e., after a certain number of stimulations the magnitude of the reflex gradually decreases, until it completely disappears. The fatigue is both specific and general.

6. The effect of alcohol is to reduce the size of the P.G.R. and its variability.

7. The following classes of stimulations tend to produce a well-marked reflex (a) intense stimuli, (b) sudden stimuli, (c) unpleasant stimuli. Regarding the factor of intensity however, Wechsler rightly observes, "The magnitude of the reflex is in no way dependent upon the intensity of its sensory stimulus except in no far as this has affective significance to the individual experiencing it."

8. Often a mere *threat* to give an unpleasant stimulus produces a higher reflex than its actual execution.

9. An *auditory* stimulus usually provokes a higher reflex than a *visual* stimulus conveying the same idea.

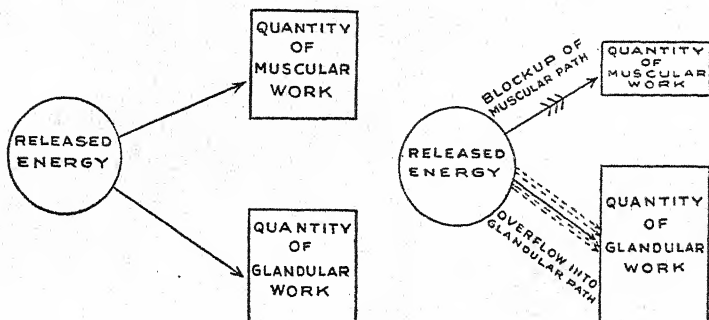
10. An emotion which is inhibited generally produces a higher P.G.R. than if it were given free expression to. Mental defectives and hysterical patients who show violent marks of emotion outwardly give very low P.G.R. Waller reports that any attempt to suppress an emotion usually enhances the reflex.

This might be explained by the hypothesis that during

a state of emotional excitement, the energy that is suddenly released, if denied adequate expression through muscular channels, tends to drain away into the glandular systems, which for the moment happen to be the most facilitated. The hypothesis might be schematically represented thus :—

WHERE EMOTION IS GIVEN FREE
OUTWARD EXPRESSION.

WHERE OUTWARD EXPRESSION OF
EMOTION IS INHIBITED.



11. The reflex is largely out of control of the patient. There is however, a sense in which the patient might abolish the reflex, *i.e.*, if he manages not to attend to the stimulus by putting himself in a stuporous condition. Conversely a patient might produce a spurious reflex for an apparently non-emotional stimulus by thinking of some exciting situation. But he cannot produce a P.G.R. by merely 'willing' that he shall get excited any more than he can 'suppress it by' willing.

12. The P.G.R. is obtained even for materials which are below the threshold of consciousness. Jung, Morton Prince and Whateley Smith have used the P.G.R. as 'complex' indicators. The reflex enables us to detect emotional material which the patient does not recognise because of habitual repression.

13. Individuals tend to be emotional towards particular types of situations. There appears to be nothing like general emotional excitability corresponding to the popular conceptions of the *excitable* and the *stolid*.

An individual does not react affectively to all stimuli, but only to some. People differ from one another with respect to the kinds of objects that excite them. Probably the popular belief regarding the general emotionality of the patients arises from the fact that some persons are apt to be more *expressive* than others of whatever emotions they experience.

14. The P.G.R. enables us to differentiate between a *genuine* emotion and a *feigned* emotion, as in many forms of hysteria. The simulation of emotion, it appears as though, can extend only to striped muscular behaviour, and not to glandular behaviour.

Although on the theoretical side the present position of the Psycho-galvanic reflex is far from satisfactory, it has been put to a large number of practical applications in the fields of Education, Medicine, Aesthetics, and Criminology. Chief amongst its clinical applications, might be mentioned its value as a 'Complex' indicator, and its help in discriminating between hysterical and organic anaesthesias, and analgesias. In the study of aesthetic experience, (such as is involved in the enjoyment of a musical selection, a picture, a poem, or a humorous situation), the P.G.R. affords a new and fruitful avenue of approach.

THE PSYCHO-GALVANIC REFLEX AS AN INDICATOR OF CONSCIOUSNESS OF GUILT.

From the detection of 'Complexes' (or the unwittingly suppressed ideas) to that of wilfully suppressed material, as in the case of a criminal trying to evade detection, is but a short step. The P.G.R. possesses the following special advantages over other modes of objective measurements of 'emotions,' which renders its application to crime detection, particularly feasible.

1. The P.G.R. is capable of revealing the presence of 'emotions' which are so low as to escape introspection.
2. The P.G.R. can lead to the detection of emotionally toned ideas which the patient will not own even to himself.
3. The P.G.R. is largely independent of the will of the patient, in fact any attempt to control the reflex will ordinarily increase the magnitude of the reflex.

As against these advantages however, must be considered the following draw-backs:—

1. As the P.G.R. indicates only the degree of emotion irrespective of its quality, an innocent person might conceivably yield a higher P.G.R. than a guilty one, on account of the *fear* emotion aroused in him by the mere fact that he is apprehended by the police on suspicion.
2. Individuals might differ in their excitability to any given situation; in fact a confirmed criminal being used to police methods might show less excitement than an innocent person.

As to how far these and other difficulties have been overcome will appear presently from a description of the procedure adopted in conducting the test.

EXPERIMENTAL PROCEDURE.

The Questionnaire.—With the help of the investigating police officers a series of questions is first prepared. They are chiefly of two kinds, (a) those that do not relate to the crime under investigation, and, (b) those that directly arise out of the crime.

I. The *non-criminal* questions, which bear upon the every day life of the patient; *e.g.*, What is your name? What is your profession? Are you married? How many children have you? Do you often fall ill? Have you any debts? How much do you earn, etc. This group of questions serves as a practice period for the patient to familiarise himself with the test conditions. Also, it helps the experimenter to obtain some idea of the normal reactivity of the patient, *i.e.*, to estimate what degree of galvanic deflection might be expected in response to questions calculated to provoke, in a high degree, his emotional susceptibilities.

II. The criminal questions refer to the various details of the offence, such as the scene and the time of occurrence, the mode of operation, the accomplices, the motive for crime, etc.; in fact, it covers all the materials gathered by the investigating officer which appear to incriminate the patient. To give a few sample questions:—Do you suspect any one in connection with this crime? Where were you on Friday night at 10 o'clock? Did you count the money before handing over charge of office? When did you first come to know of the occurrence of the crime? Can you swear that you are innocent?

The following considerations have to be borne in mind in framing the questions are:—(a) The questions must be in the vernacular of the patient; (b) they must be short and simple so as not to tax his capacity to understand; (c) it ought *not* to be possible to answer them automatically with a simple 'Yes' or 'No;' but each question must be so framed, that it has to be attended to, before a suitable answer can be given; (d) no question may be put in a form that directly accuses the patient; and (e) there must be a large battery of questions of each type so as to neutralise the play of chance elements.

Instructions to patients.—The following general instructions are given to the patient before starting the experiment:—

"We want to find out the truth about this case. You are here to help us. If you are innocent you have no cause to be anxious, for the apparatus never makes a mistake. It will not hurt you in any way. As you are innocent you have nothing to fear. Now I am going to ask you a few questions. Answer them truthfully and briefly. Always answer to the point, and do not begin to explain away in long sentences. Being innocent yourself, I am sure you will help me to find out the real culprits."

After 'balancing' the patient on the Wheatstone Bridge as per Wechsler's method described above on page 2, the experimenter proceeds to put the question to the patient and records the resulting galvanic deflections. Only such deflections as are obtained within 3 to 4 seconds after presenting the question are recorded, the others being neglected on the assumption that they most probably do not refer to the questions immediately preceding. An exact record of the oral responses of the patient is also kept by an assistant. Short notes are made of peculiarities in the behaviour of the patient while answering the questions, *e.g.*, coughing, yawning, stammering, sighing, fidgeting, laughing, swallowing, shivering, delaying response, misinterpreting the questions, etc.

The Experimental Results.—Altogether 30 persons have so far been tested in the laboratory for various alleged offences, including, copying in examinations, minor theft, house-breaking and theft, high-way robbery, treasury defalcation and misappropriation, and murder. Conclusive evidence regarding their guilt or innocence was available only in 12 cases. In the remaining 18 cases, as sufficient external evidence was not available either to corroborate or disprove the psychological finding, the results cannot be considered to be of much scientific value. In the following tables of results, therefore, these doubtful cases are not included.

TABLE I.
EMOTIVE REACTIONS OF PERSONS OF 'PROVED GUILT.'

No.	Patient.	Alleged offence.	Median Reaction.	75% ile Reaction.	Inter Quartile Range.
1	Shroff Honniah	Treasury Defalcation and Misappropriation of funds.	Cr. 10·0 Non. Cr. 3·0	16·0 7·0	13·0 6·0
2	Sheristedar A. . .	Do.	Cr. 0·5 Non. Cr. 0·2	1·0 0·5	0·8 0·5
3	Head Clerk ..	Do.	Cr. 0·5 Non. Cr. 0·5	2·0 1·5	2·0 1·5
4	Mada	House-breaking and theft.	Cr. 1·0 Non. Cr. 0·5	2·0 1·0	2·0 1·0
5	Joseph ..	Do.	Cr. 0·5 Non. Cr. 0·2	2·5 1·0	2·5 1·0
6	Siddoji ..	Do.	Cr. 0·5 Non. Cr. 0·5	2·0 1·0	2·0 1·0

EMOTIVE REACTIONS OF PERSONS OF 'ASCERTAINED INNOCENCE.'

7	Sheristedar B. . .	Treasury Defalcation.	Cr. 3·0 Non. Cr. 4·7	3·5 5·5	2·5 4·5
8	Mahomed Kasim	Murder.	Cr. 0·0 Non. Cr. 0·0	0·2 0·2	0·2 0·2
9	Mada (Mental defective)	Do.	Cr. 0·2 Non. Cr. 0·2	0·5 0·7	0·5 0·7
10	Boliah ..	Do.	Cr. 0·5 Non. Cr. 1·2	1·7 2·5	1·7 2·0
11	Shammanna ..	Do.	Cr. 0·5 Non. Cr. 0·5	1·0 1·0	0·8 0·8
12	Gopala Setty ..	House breaking and theft.	Cr. 8·0 Non. Cr. 8·0	16·0 16·0	12·0 12·0

The relative standing of the emotive reactions for the criminal and the non-criminal questions could be more easily appraised if a single measure of criminal index for each patient can be arrived at. A rough estimate of 'criminal consciousness' might be obtained by dividing in each case the reactions for criminal questions by those for the non-criminal questions. Since there are three different standards of comparison, criminal indices might be obtained in three ways, thus :—

A. On the basis of Median Reactions :—

$$\text{Criminal Index I} = \frac{\text{Median Reaction for Crml. Questions}}{\text{Median Reaction for Non-Crimnl. Questions.}}$$

B. On the basis of the 75%ile Reaction : —

$$\text{Criminal Index II} = \frac{75\%ile \text{ Reaction for Criminal questions.}}{75\%ile \text{ Reaction for Non-Criminal Questions.}}$$

C. On the basis of variability :—

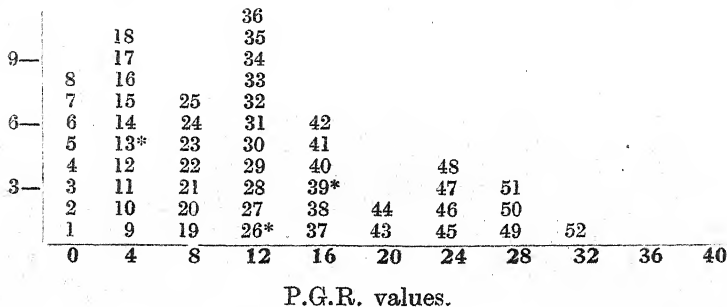
$$\text{Criminal Index III} = \frac{\text{Inter-quartile-range for Crimnl. Questions.}}{\text{Inter-quartile-range for Non-Crimnl. Questions.}}$$

Again, another convenient method of comparing the reactions of the 'guilty' and the 'innocent' would be on the basis of the *percentage of criminal questions which exceed the 75%ile reaction for the non-criminal questions.*

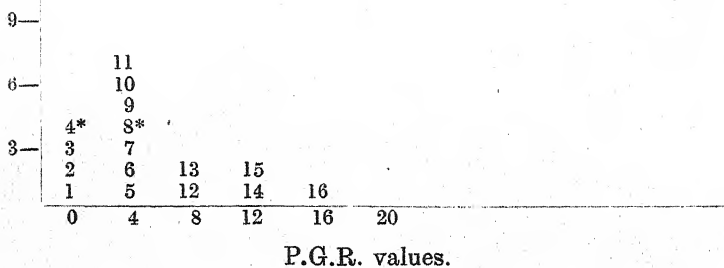
To give an instance, in the following distribution of P.G.R. values, the 75%ile reaction for non-criminal questions, is found to be 8.0 and the percentage of criminal questions exceeding this limit is 50.

Criminal Index IV=Percentage of criminal questions exceeding the 75%ile reaction for non-criminal questions.

EMOTIVE REACTIONS FOR CRIMINAL QUESTIONS.



EMOTIVE REACTIONS FOR NON-CRIMINAL QUESTIONS.



Note:—* Indicates the positions of the 25%ile, the 50%ile, and the 75%ile reactions.

The Criminal Indices obtained for the different patients by dealing with their emotive reactions in the manner described above, are reported below in Table II, as Criminal Index IV.

TABLE II.
PERSONS OF 'PROVED GUILT.'

No.	Name.	Offence.	CRIMINAL INDEX.			
			I.	II.	III.	IV.
1	Shroff ..	Treasury Defalcation ..	3·3	2·3	2·2	65%
2	Sheristedar A ..	Do.	2·5	2·0	1·6	36%
3	Head Clerk ..	Do.	1·0	1·3	1·3	28%
4	Mada ..	House-breaking and theft	2·0	2·0	2·0	42%
5	Joseph ..	Do.	2·5	2·5	2·5	42%
6	Siddoji ..	Do.	1·0	2·0	2·0	29%

PERSONS OF 'ASCERTAINED INNOCENCE.'

7	Sheristedar B. ..	Treasury Defalcation ..	0·6	0·6	0·4	9%
8	Md. Kasim ..	Murder ..	1·0	1·0	1·0	14%
9	Mada (Mental defective).	Do.	1·0	0·7	0·7	24%
10.	Boliah ..	Do.	0·4	0·7	0·8	16%
11	Shammanna ..	Do.	1·0	1·0	1·0	17%
12	Gopala Setty ..	House-breaking and theft	1·0	1·0	1·0	16%

Criminal Index I :—Comparison on the basis of the Median Reaction.

Do. II :— " " 75%ile Reaction.

Do. III :— " " Variability (I. Q. R.).

Do. IV :— Percentage of Cri. Ques. exceeding the 75%ile reaction for the Non-Criminal Questions.

GENERAL CONCLUSIONS.

The relative worth of the different Criminal Indices might now be noticed.

A. *Criminal Index I.*—Discrimination on the basis of the Median Reactions seems to be the least effective, for we find that two persons of 'proved guilt' obtain the same Criminal Index, (*viz.*, 1.0), as four persons who are known to be innocent.

B. *Criminal Index II.*—A comparison on the basis of the 75%ile reaction, appears to be more reliable. The coefficients here do not show any overlapping. In all cases of known innocence the indices are 1.0 or below 1.0; similarly in all cases of established guilt the indices are 2.0 or above 2.0, except in one case, where it is 1.3. The lowest index for any guilty person is well above the highest index of the innocent.

C. *Criminal Index III.*—Differences in the Inter-quartile-range, also appear to provide effective means of discriminating between the guilty and the innocent.

In every case of known innocence, the coefficient is 1.0 or below 1.0, while in all cases of proved guilt it is distinctly above 1.0, the index never falling below 1.3.

D. *Criminal Index IV.*—Every case of 'proved guilt' has a Criminal Index of 28% or more, while every case of known innocence has an index of 17% or less, with the exception of Mada the defective. Comparisons on the basis of the percentage of Criminal Questions exceeding the 75%ile reaction for the Non-criminal questions might therefore be said to be fruitful of results. We have noted a few exceptions to the general tendencies stated above. As against this, however might be noted the fact, that no two indices yield results of doubtful value for the same individual. It might be taken therefore, that a judgment based on a consideration of all the four criteria, is not likely to fail.

To sum up, the following conclusions appear to be warranted:—

1. The 75%ile Reaction is more diagnostic than the Median Reaction.
2. Differences in I. Q. R. also afford important means of distinguishing between the guilty and the innocent.
3. It is safer to rely on the combined evidence of two or more criteria, than on any one of them.

Other results, though perhaps of minor import, which appear worth reporting are:—

1. Both innocent and guilty persons tend to give very high emotive reactions when they are asked to

swear, in the name of their family deity, that they are innocent.

Not so, however, the emotive reaction to the question 'Do you suspect anyone in connection with this crime?'

Here the P. G. R. for guilty persons generally tends to be very high whereas it is either low or moderate in the case of innocent persons.

Now we shall pass on to the consideration of another class of experiments which might be called artificial or laboratory crimes.

LABORATORY CRIMES.

Introductory.—The advance of the technique of the psychogalvanic method of crime detection, would be a very slow process, if we had to wait for real cases of crime to be brought up to the laboratory for investigation. It is not every day that the police department can find the necessary time to bring up suitable material for investigation. It was thought therefore that a rapid advance of the technique would be facilitated by simulating under Laboratory conditions, the essential features of *criminal consciousness*, which for our purposes might be taken as:—

- (a) the commission of an act by the patient in secret,
- (b) an attempt on the part of the experimenter to detect it, and
- (c) resistance on the part of the patient.

Laboratory crimes have a further advantage, in that they provide a ready means of either proving or disproving the result of the psychogalvanic testing, on independent external evidence. We have already noticed how this was not possible in as many as 18 cases of the real crimes. At this stage of the research an objective check for the psychological finding seems most essential.

Experimental Procedure.—The instructions given to the patient are:—

'You will take this pack of 20 playing cards into the next room and take out from the pack at random any one card. You may shuffle the cards if you like before picking out one of them. You are allowed to see only that card which you select. Do not attempt to see the others. Hide the selected card carefully in your pocket. You will keep the other cards also with you, till the end of the test. When you come back to this room I shall with the help of this instrument, find out which card you have selected, however much you may try to hide it from me.'

The instructions given after the patient has chosen a card and has returned to the experimental room are:—

'I know all the 20 cards in the pack. I will call one by one all the names of the cards. You will repeat the names after me and then say 'Yes' or 'No.' By 'Yes' you mean that, that it is the card selected by you; and by 'No' you mean that it is not the card. You may give false replies if you like. You may say 'Yes' and 'No' as many times as you like. In fact you will try your very best to deceive me. You may adopt any method of deception you choose. It is my business to find out the card in spite of your efforts to hide it from me.'

After connecting the electrodes to the patient, and having 'balanced' his hand resistance on the Wheatstone Bridge as already described above, the experimenter proceeds to repeat one by one, the names of the cards. The oral responses and the psycho-galvanic reactions of the patient to each stimulus are recorded. The first four stimuli are fictitious; these cards are not in the pack. This is done to give time to the patient to adjust himself to the experimental conditions in general. After the whole series had been presented once, the experimenter judging mainly by the magnitudes of the reactions, selects 4 or 5 cards as the likely ones, and proceeds to repeat them a second time. It is necessary in the second repetition also to begin with 2 dummy cards, to enable the patient to get over the surprise of having some cards presented twice.

The probable cards are presented a second time so as to exclude the vitiating effects arising from extraneous and accidental sources, such as sudden alterations in breathing disturbances of contact in the electrodes, changes in the direction of attention, the touching of a 'complex', etc. In deciding upon the probable cards that deserve to be repeated the following further considerations should be borne in mind:—

(1) Repeat all cards for which the patient says 'Yes' where they are few in number, and (2) all cards for which the patient delays response, coughs, or stammers.

Again the probable cards are presented a third time, but this time visually and the resulting emotive reaction recorded.¹

The experimenter would then name the card which gives consistently high emotive reaction as the one chosen by the patient. The experimenter also notes his feeling of certitude regarding his prediction. An introspective report of the patient, obtained immediately after the test, bearing particularly on the following points, is recorded:—

¹ The above is an account of the standard procedure now adopted, after considerable modification, in the light of earlier failures. The earlier procedure consisted in first presenting all the cards *visually*; and there were no repetitions of the probable cards. The card showing the highest P.G.R. in the first reading was declared as the chosen card.

- (1) Did you feel in any way excited for the crucial card?
 (2) What was your method of deception?

After the experimenter has thus declared a card, as the chosen one, the patient says whether the prediction is correct or not. If it is not correct, the patient has to say what the correct card is, before taking the card out of his pocket. This is to make sure that the patient had remembered the card at the time of the test, for otherwise, the card could not be expected to yield a high emotive reaction. If the card indicated by the psycho-galvanic reflex was the same as the one chosen by the patient, the test is counted as *successful*, if not as a *failure*.

EXPERIMENTAL RESULTS.

Altogether 81 tests have been conducted over a period of two years with 73 persons differing widely in age, experience, social standing, and education.

In 47 cases out of 81, (*i.e.*, 58%) the experimenter was able to pick out the chosen card correctly guiding himself solely on the basis of the psycho-galvanic-reflex. If left to pure chance the success might be expected to be only 1 in 400.

59% success must be considered to be very high in view of the fact that many of the tests were conducted as demonstration experiments in the presence of a large number of visitors to the laboratory or in the lecture hall before a large gathering of students. These demonstration experiments tend to lower the percentage of success, as the audience acts as a source of distraction to the patient.

TABLE III.

	NUMBER OF		PERCENTAGE OF	
	Successes.	Failures.	Success.	Failure.
Demonstration Tests..	15	13	53%	47%
Laboratory Tests ..	32	21	60%	40%

Again the earlier procedure of single visual presentation of cards without repetitions of the doubtful cards, tends to lower the percentage of success, as might be gathered from the following table.

TABLE IV.

Procedure.	NUMBER OF		PERCENTAGE OF	
	Successes.	Failures.	Success.	Failure.
Single visual presentation	17	17	50%	50%
Repeated oral presentations.. ..	30	17	64%	36%

The Improvement in technique effected during the course of the investigation might be indicated from the scores presented in Table V below.

TABLE V.

	NUMBER OF		PERCENTAGE OF	
	Successes.	Failures.	Success.	Failure.
The first 40 tests ..	20	20	50%	50%
The second 40 tests	27	13	67%	33%

Some Sources of Error.—Every failure of the test, although in many cases disappointing to the patient and to the spectators, constituted a challenge to the experimenter, and is of scientific value, for it leads to the tracing of the many sources of error which are likely to arise in the psycho-galvanic method of crime detection. In some cases of failures the error was not traceable.

A close examination of the procedure, the introspective account and of the records, immediately after the test, usually suggests some sources of error. The chief amongst them are given below:—

1. The patient intentionally pressing the electrodes and thereby altering the pressure or the area of the surfaces of contact.

2. The questions being put without a warning signal.
3. Abrupt variations in the *form* of the question as distinct from its *content* cause surprise, fear, anger, laughter, and other emotions in the patient.
4. Unfamiliarity on the part of the patients with playing cards, makes them confuse one card with another.
5. The patient not understanding the instructions to 'Deceive,' makes no attempt to suppress the information. He answers in a matter of fact way 'No' to all cards but the one he has chosen.
6. Accidental distractions, when the crucial card is presented. Some patient do not notice the card being presented at all,—their attention having been momentarily distracted.
7. Extraneous emotional associations with the card names, *e.g.*, some patients thought of "Queen of my heart," when Heart Queen was presented.
8. Concurrent intellectual operations like looking intently at the galvano-meter scale for indications of one's own emotions. Such intellectual pre-occupation tends to arrest the normal development of an emotional excitement.
9. The crucial card coming too early in the series, *i.e.*, before the patient has settled down to the experimental conditions.
10. Failure on the part of the patient to *repeat* the names of the cards after the experimenter
11. Patient forgetting the card he has chosen during the course of the experiment.
12. Not making repeated presentations of the doubtful cards.
13. In exceptional cases a patient is also apparently able to mislead the experimenter with some other card which he has previously decided upon.

* * *

I am keenly conscious of the fact that the results reported above are merely suggestive and not well established. My aim in presenting them now is to show the possibilities of the science, and attract other votaries to this line of research, which is so promising, and fraught with such immediate benefit to society. More research is necessary in this direction before a fool-proof technique could be perfected, safe enough to be placed in the hands of the detective officers. The improvement effected during the course of the last two years by advancing the percentage of success from 50 to 67 makes me hopeful of even better results in the years to come, provided sufficient facilities are forthcoming.

The setting up of a whole-time agency for the pursuit of this problem seems a most urgent one; for, its solution, will

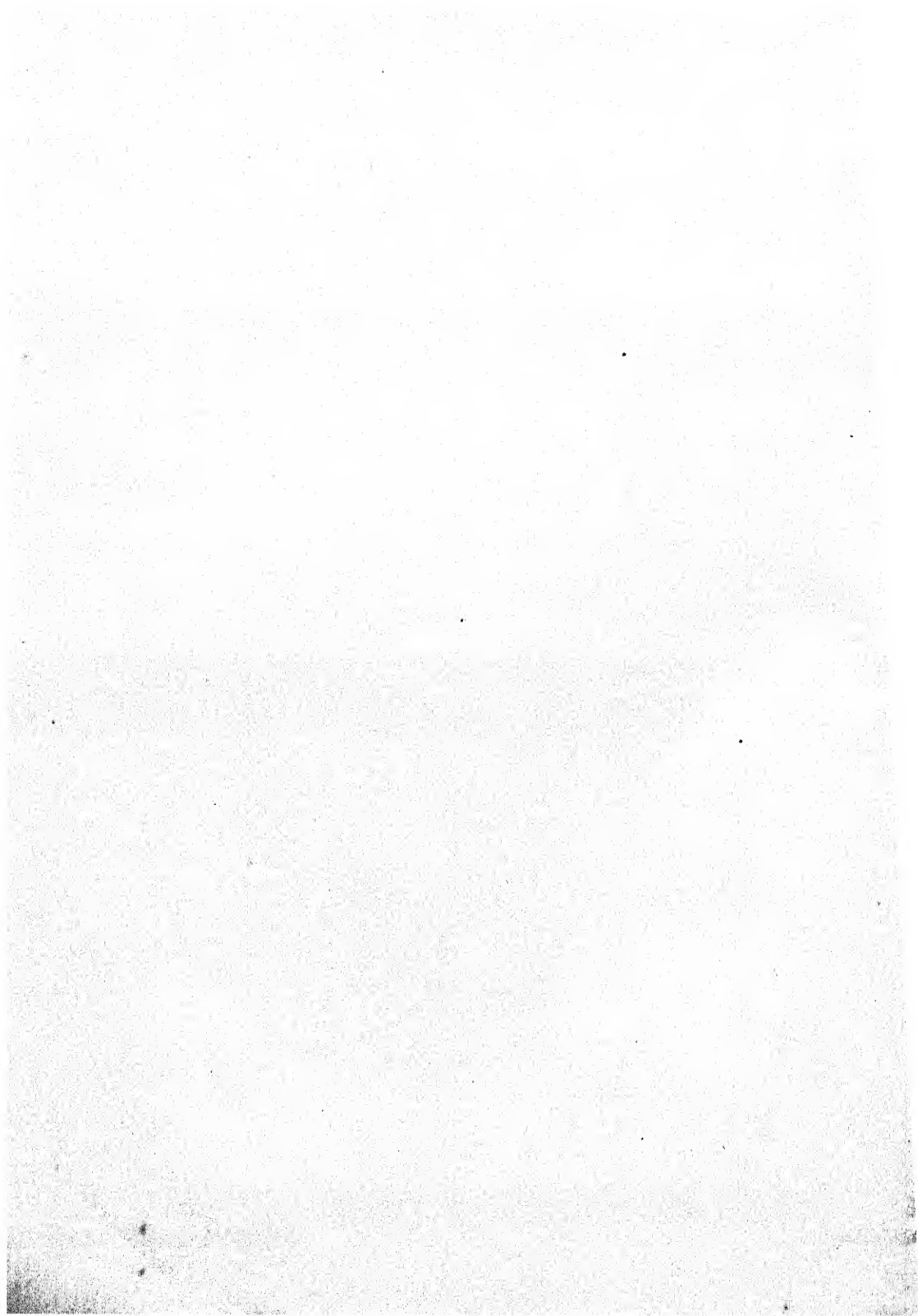
render invaluable help to the police and the law courts. Many crimes which now go unpunished for want of 'evidence' could be traced to their proper authors. The psycho-galvanic test affords a new, and the only way of approach where other evidence is lacking. May we hope that the Government of India will be able, before long, to do something in this direction. Private initiative and philanthropy, will, I have no doubt, go a long way in giving the necessary impetus to governmental action.

* * *

Before concluding my address, I should like to refer to one or two other matters. I think it is Sir J. C. Bose that said that Indians are a pre-eminently introspective people. Is it not surprising that in the face of this excellent certificate, we should be doing so little for Psychology, while the Americans, than whom probably there are none more extrovert, should talk so much about Psychology,—behaviour or no-behaviour.

Let us hope that the Indian Universities will recognise that 'the proper study of man kind is man,' and in the near future accord to Psychology its proper place, not only in their curricula of studies, but also in their budgets, more in keeping with its modern developments, needs and affinities.

I believe you have all seen the announcements regarding the forthcoming International Congress of Psychology. May I request all of you to join the fellowship, although it may not be possible for all of us to attend the Congress in person. Some of us who may happen to be in America at that time, might represent India at the congress and convey our greetings.



Section of Psychology.

Abstracts.

1. Varieties of intelligence.

O. BERKELEY HILL, Ranchi.

In spite of intensive study the definition of intelligence remains a matter for dispute. The classical view of Aristotle. Descartes deduced from it the doctrine of all men being endowed with reason and good sense. This doctrine treated as a metaphysical concept until the 18th century philosophers, who had a political axe to grind, used it to support the doctrine of democracy. To-day we see a reaction to this doctrine among psychologists and philosophers. The most notable theory is that of Jung who describes two main types of intelligence—extravert and introvert. Incompatibility of these two types. Extravert intelligence typical of western intelligence. Introvert intelligence typical of eastern intelligence. Failure of extravert intelligence to deal with spiritual activities of man. Failure of introvert intelligence to deal with the common needs and common interests of man. Extravert and introvert attitude towards sociological development. Influence on relations between Europe and Asia. Unsuitability of democratic form of government for mankind in general and for Asiatics in particular. Dire prospects of India and China if the democratic ideal becomes a form of religion as it has in Europe and America. Only hope of happy issue seems to lie in proper psychological education. Psychologists deeply involved.

2. A psychological analysis of ability with symbols and its relation to mathematical ability—A preliminary investigation.

A. A. KRISHNASWAMY AYYANGAR, Mysore.

This paper is an attempt to consider a psychological analysis of ability with symbols and its bearing on mathematical ability.

To gather some preliminary data for detailed investigation, a test of ability with symbols is constructed, involving the interpretation and use of symbols, some with and others without mathematical content.

1. There is such a thing as ability with symbols.

2. There is a twofold aspect in symbols. One is the stripping of their ordinary content and the other is the substituting in lieu of it, a content of arbitrary choice of any degree of complexity. This requires the exercise of two mental processes of abstraction and concentration.

3. Perfect mastery of the mere contents of symbols is not enough. The symbols have their own laws of combination—a grammar and syntax—just in the same way as words, but playing a more important rôle. It may not be difficult to construe a sentence written in bad grammar and spelling, but symbols manipulated carelessly with imperfect knowledge of their laws of combination lead to gross errors and sheer nonsense.

4. A mathematical course does provide a certain amount of training in the appreciation of symbolic content and manipulation, but in a half-and-half mathematical education, there is the danger of one being obsessed by the mathematical notation to the extent of misapplying it in inappropriate situations.

5. Native ability with symbols helps one to avoid the pitfalls in the

application of mathematical symbols and bear with ease the strain of abstraction and concentration involved in symbolic work.

3. New light on dream-psychology from Upanishadic sources.

R. NAGARAJA SARMA, Madras.

(1) Prof. J. T. MacCurdy of the Cambridge University while recognising the value of the Upanishadic hypothesis to which the writer of the paper had drawn attention in his previous contributions to the Psychology Section of the Indian Science Congress maintains that the Upanishadas do not formulate the laws according to which images of the Unconscious Realm—the Vasanas combine to project dream imagery.

(2) The laws of waking life such as those of association would *mutatis mutandis* explain dreams phenomena as well.

(3) Criticism of MacCurdy's theory of dreams, and the hypothesis of "Reintegration" advanced by Prof. Hollingworth.

(4) Examination of a significant text from the Mandukya-Upanishad. The Subject is obliged willy-nilly to pass through four states—waking life, dreams, dreamless sleep and a fourth which transcends the previous three.

(5) Reference to and discussion of the Brihadaranyaka text in which transition from sleep to dreams, and from both to waking life is described.

(6) Elaboration of the Brihadaranyaka theory of "Fatigue" of the sense organs.

(7) Brihadaranyaka hypothesis of dreams as affording escape from the tyrannical realities of waking existence. The escape is not the Freudian wish fulfilment nor the solution of conflict of Dr. Rivers.

(8) Dreams as compensations made by nature's own arrangement for individual differences of waking life in endowment, equipment, and environmental opportunities and facilities.

(9) Dreams, like the whirling of time bring on their own revenges. Biter of waking life is bit in dreams!

(10) The most important contribution made by the Upanishads is the emphasis on the truth that the dream state along with waking and sleep states is to be transcended and a higher state of existence is to be aimed at. Western theories of dreams so far formulated have not noticed the matter at all. Western theories are guilty of an unmethodological mixing up of the clinical with psychological material. The Upanishadic hypothesis is more comprehensive and less risky and vulnerable.

4. Errors in essay valuation—an experimental investigation.

N. VENKATANARAYANA SASTRY.

Introductory.—Most of the errors in school and college examination valuations arise from the fact that the answers are in the form of essays. The paper attempts to measure the degree of error present in such valuations.

Plan of experiment.—50 teachers valued the essays of 23 pupils of the IV form, on a scale of 20 points, with 35% as the pass minimum. Each teacher when he valued the papers did not know the marks given by the other teachers. The results were classified under the following four groups—(a) Failure—less than 35%, (b) Just pass—between 35 and 49%, (c) Second class pass—50 to 59%, and (d) First class—60% and above.

Experimental Result.—It was found that 15 out of 23 pupils had been placed in all the four classes mentioned above, and not a single essay had been placed in the same class by all the 50 teachers. 16 out of 23 pupils

had scored first class marks from some one or other of the teachers. All the 23 pupils had been made to fail by at least 3 out of 50 teachers.

The degree of agreement amongst the various examiners was also estimated by the method of inter-correlations. For this purpose only 8 teachers of proved ability and experience were taken. The median value of 27 inter-correlations was found to be 0.522 with a probable error of 0.106.

5. Hunger *vs.* escape as motives in animal learning.

B. KUPPUSWAMI, Mysore.

McDougall has pointed out that *hunger* as motive to learning in white rats is very unsteady. The present paper reports an attempt to measure the relative efficiencies of *hunger* and of *escape* as motives to learning a water-maze. Two groups of white rats were used for this purpose. The water-maze to be run through by the rats consists of glass partitions which would compel the rats to take a course roughly resembling the shape of letter W. In the case of the hunger group the rats had to dive under water to pick up food grains. They would have to take to water spontaneously to obtain the food-grains. The rats of the escape group on the other hand were thrown into water and in their attempts to get out of water must learn to thread the maze. The basis of comparison between the two groups being the amount of habit fixed at the end of 30 days' training, and the number of mistakes made in the process of learning. It was found that the 'escape' group learnt much more quickly than the 'hunger' group; also the learning curve of the 'escape' group was more steady. But nearly 30% of the rats of the 'escape' group formed a distinct emotional 'complex' for the task and would not learn at all.

6. Instinct and consciousness.

A. S. WOODBURN, Madras.

Experiments on decerebrate animals have shown that such animals are still capable of the principal forms of instinctive behaviour. Apparently the cerebral centres are not required for behaviour on the instinctive level; it needs the operation of the sub-cortical centres only. This led Professor Lloyd Morgan to the conclusion that when consciousness is present in such behaviour, it functions only as a spectator. Even if such a case were established for lower animals, there still remains the problem of whether human beings would react in the same way. Evidence is meagre, but we have the case of the decerebrate boy reported by Edinger and Fischer who lived for three years and nine months without a cerebral cortex, but showed no evidence of being capable of instinctive responses. The evidence seems to show that the absence of a cortex in the human animal creates a much greater disturbance than in the lower animal. The neencephalon appears to be necessary even in instinctive behaviour. The psychoneural organism is a unity, and it is a mistake to think that the higher brain centres are quite inoperative even in the simpler forms of responses. Human psychology must admit an element of consciousness in instinctive behaviour.

7. On the use of ropes as means to securing food-objectives by elephants, monkeys, and dogs.

G. H. HANUMANTHA RAO, Mysore.

Köhler has shown that the use of tools to secure objectives is a mark of intelligent thinking. The present paper reports a series of experiments designed to bring out the difference between the elephant, the monkey, and the dog in the use of ropes as *tool*.

Experiments. I Series.—Food is tied to one end of the rope and the animal placed at the other end. Its efforts to reach the food and the reaction time are noted. The elephants and the monkeys draw the food almost immediately.

II Series.—The food is tied to one end of the rope, which is placed in the form of the letter 'V,' and the animal left at the apex. The side to which the food is tied is varied at random in a series of trials. Sundar Gaj, and Jang Bahadur two elephants belonging to His Highness the Maharaja of Mysore, made the correct choice every time for 10 trials.

III Series.—Four ropes are placed alongside of each other running in straight lines away from the animal. The food is tied to one of these ropes. The position of the food is changed at random. The choice of the animal and the reaction time are noted. Out of 11 trials Jang Bahadur pulled at the correct rope 8 times. Each time he made a mistake he pulled at the rope which was last tied to the food.

IV Series.—Four ropes were crossed one over the other, and the food tied to one of them each time at random. Sundar Gaj experienced considerable difficulty in learning this new situation. In the first six trials she made the correct choice only twice, and in the next six trials four times. Comparative scores of the monkeys and the dogs are also reported, which show that the abilities of the elephants and that of the monkeys are about equal, whereas the performance of the dogs is distinctly inferior.

8. Juvenile delinquency,—a study of 50 cases.

FRANK NORONHA, Bangalore.

The factors determining criminal conduct are diverse and complex. Criminal conduct may be the result of conflict. Young delinquents are more amenable to reform as their problems are less complicated.

Results of 50 cases investigated, noted under the following heads,—illiteracy, physical defects, defective parental control, primogeniture, lack of proper occupation, influence of accomplices, and irregular family life.

Unfavourable domestic environment is the principal feature noted in this investigation. Futility of current method of dealing with them by fixed terms of imprisonment. Institutional life and individualised treatment advocated.

9. The distribution of spelling attainments in the Mysore city schools.

A. C. DEVA GOWDA, Mysore.

The paper reports upon a recent survey of the spelling attainments of the pupils of the first four schools grades in the Mysore city schools. The spelling test as standardised for the London schools by Professor Cyril Burt was given to 722 pupils belonging to different schools. The median values for the different classes tested are given below, along with the corresponding norms for London pupils of the same number of years of schooling.

Burt's Spelling Test.

		NO. OF YEARS OF SCHOOLING.				
		First Year.	Second Year.	Third Year.	Fourth Year.	Seventh Year.
Mysore City Norms	..	18	28	36	52	73
London Norms	..	17	27	36	45	73

The close similarity between the two norms appears more striking in view of the fact that the two groups differ in respect of sampling, age, and mother tongue.

10. The psychological approach to religion.

R. RAMANUJACHARI, Chidambaram.

What religion is.—Religion an attitude of dependence on the universe. Implies God-Consciousness; includes feelings such as creature-hood, reverence, awe, etc. No mere tangle of metaphysical subtleties, celestial preoccupation; nor a record of emotional adventures, floundering in feelings; nor a collection of magical formulas to secure safety and merit. Attitude of entire human personality to the whole of existence.

Scope and standpoint of psychology.—Psychology, systematic study of the entire field of human experience and therefore interested in religious experience. Humble task of observation and description. Employs genetic methods. Metaphysical explanation of experience outside its province.

Psychological study of religion.—Experimental investigation of religious phenomena possible.

Sources of information.—Psychology of religion examines biographies and autobiographies of saints and religious workers; introspective workers; introspective evidence; religious records, mythologies, folklore, etc.; religious practices; results secured by the questionnaire method.

Caution.—In the pursuit of an inexact science constant danger of rushing to conclusions. This possibility to be guarded against. Some instances of hasty generalisation—Psychoanalysts' view of religion as grounded in the unconscious, a projection of subjective sense; notion of mysticism as a form of Narcissism; views of religion as rooted in some one instinct, sex or fear.

11. The language factor in intelligence tests.

N. S. NARAYANA SASTRY, Mysore.

Introductory.—The investigation was undertaken to find out, how far, if at all, the fact that an intelligence test given in a foreign language (English) would tend to vitiate the test results.

Procedure.—The analogies and the opposites tests were given to 100 pupils of the IV Form class. The test was given both in Kannada and in English. For some batches the Kannada tests were given first and for others the English tests.

Results.—The subjects as a whole obtain higher scores in the Kannada tests, but their ranking remains much the same. The Correlation Co-efficients are—

Opposites test	$r = 0.79$	P.E.r = 0.0242
Analogies test	$r = 0.94$	P.E.r = 0.0066

Conclusions.—The fact that the analogies and the opposites tests were given in a foreign language (English), does not appear to vitiate their value as intelligence tests.

12. An investigation into the method of work of Shamanna a 'mathematical prodigy.'

V. VENKATACHAR, Mysore.

Introductory.—Shamanna who shows extraordinary quickness in mental arithmetic, is 40 years old. He has had no education beyond the

III Form in which class he failed a number of times. He shows an extreme lack of interest in everything other than numbers. He is considered to be a mental defective by his parents and neighbours. He attributes his mathematical feats to divine interference, and spends several hours in meditation and worship. While doing the problems he chants some mantras and sways his body to and fro in the manner of a medium. The experiment was undertaken to obtain insight into the method of work employed by the 'prodigy.'

Procedure.—The problems given were—multiplication, division, finding the squares of given numbers, conversion of pies into rupees, giving week-days for given dates, etc. The responses and the reaction times were noted by the experimenter. Besides Shamanna, 4 mathematics graduates of proved high ability were tested in the same manner.

Results.—The average reaction time of the 'prodigy' was found to be about 2 to 4 times quicker than those of the others, with but one exception. The questions which were found to be difficult by the normal subjects, (judging by the reaction times), were also experienced as difficult by the 'prodigy.' These facts would appear to preclude the hypothesis of 'short-cut methods' and of telepathic communication. He appears to have recourse only to the ordinary arithmetical methods. His remarkable quickness of work might be attributed to his ability to keep numbers steadily before his mind, without the help of paper and pencil.

13. A statistical study of some examination marks.

ASWINI KUMAR DATTA, Dacca.

The study is based on the marks obtained by the candidates in five successive years in a certain public examination of Bengal. The variation of the average and the standard deviation of the marks from year to year and the classification of the results into divisions and the consequent change in the standard of the examination have been examined. Some suggestions for improvements have also been made.

14. The speed factor in intelligence tests.

K. G. RAMA RAO, Mysore.

Purpose.—The purpose of the experiment is to examine the validity of the objection to intelligence tests with *time limit*, that they place too high a premium on mere quickness, as distinguished from clearness, acuteness, and profundity of thinking.

Plan of Investigation and results.—The absurdities test was given to 98 Senior Intermediate students and 55 B.T. class students. They were given as much time as they wanted to finish the test. The time that each student took to finish the test was noted. Correlations were found between the quality of work (i.e., the number of questions correctly answered), and the speed of work. The correlation co-efficients are :—

		r	P.E _r
Senior Intermediate class	..	0.22	0.09
B.T. Class	..	0.37	0.11

Again the opposites test was given in two forms, viz., the hard opposites test (*without* time limit), and the easy opposites test (with time limit of 5 minutes) to 76 junior intermediate students.

The correlation co-efficient between the two tests is 0.63 with a P.Er of 0.05.

Conclusions.—In tests such as the *opposites test* where simple acts of thought are involved the imposition of a time limit does not appear to lower its diagnostic value.

15. Introjection and projection.

J. K. SARKAR, Muzaffarpur.

Introjection and projection are the two subtle devices contrived by the ego to defend itself against the onsets from the external world.

Introjection seems to be based mainly on object-love, whereas projection mainly on narcissism. But it is suggested here that the ego stands on the level of narcissistic gratification in both these processes.

The different forms of relation between Cs, and Ucs, underlie the different kinds of repression, projection and introjection. Repression is the outcome of rejection from Cs, and attraction from Ucs,—the result of a push from ahead and a pull from below. Projection, reprojectio and introjection result from such internal pulling and pushing.

All these various mechanisms of the mental apparatus are illustrated here by observation and analysis of some concrete cases and free associations.

Conclusion.—The ego is but a hierarchy of subordinated simulating agents—chiefly a composition of ego-child and ego-adult. In introjection it behaves like a submissive child, but in projection it acts as an aggressive adult. The mental health or normality of the ego is maintained by making the ego-child act as a counterpoise to the ego-adult and by combining them together against the intervention of the outside world.

16. Intelligence tests and university examinations.

B. KUPPUSWAMI, Mysore.

Problem.—To determine, if possible, the minimum intelligence required for securing a pass in the B.A. and the B.T. degree examinations of the Mysore University.

Procedure.—The absurdities test, the analogies test, the opposites test, and the number completion test were given to 121 freshmen of the Maharaja's College, and to 31 students of the B.T. class. So as to secure equal weighting for all the tests, the raw scores were converted into Q scores (*i.e.*, treating the semi-inter-quartile-range of each test as the unit of measurement for that test).

Results.—The B.T. degree examination results yielded a co-efficient of association (Yule's) with intelligence test results of 0.79. Of the 16 students who passed in the university examination, 11 were above average in intelligence; and of the 15 that failed, 12 were below the average in intelligence. No candidate who had secured consistently 1 or below in the intelligence tests was able to pass the university examination. The results of the B.A. degree examination for the past two years also show similar tendencies.

Applications.—Where feasible suitable advice might be given to candidates seeking admission to the various courses regarding the chances of their success.

17. Objective examination in mathematics.

MANINDRA LAL KANUNGO.

The object of this experiment was to find the relative merits of the new type examination (as communicated by Mr. Datta to the 1928 session of the Congress) and the traditional type of examination in high school mathematics as regards (a) validity or correspondence between what it actually measures and what it purports to measure, (b) objectivity of marking, (c) diagnosis of the weak points in the knowledge of the examinees, and (d) facility in holding the examination. The examinees were the boys of Class IX of a high school.

The correlations of the new as well as the old examination with the terminal examinations and teachers' ratings show that as regards validity the new examination (N.E.) is at least as reliable as the old one. The correlation between two independent examiners in the old examination (O.E.) was 0.89 and that in the N.E. was 0.96. For diagnosis some parallel questions were set in both the examinations. The questions of the N.E. were, of course, shorter. It was found that the boys who failed to do the sums of the O.E. also failed to do the corresponding sums of the N.E. It was, however, possible to ascertain by the little sums of the N.E. why they failed to do the much bigger sums of the O.E. In the O.E. some boys could give the entire proof of a geometrical proposition, the general enunciation being given, but in the N.E. they failed to give a small portion of the proof, other necessary portions being given, showing the influence of cramming in the O.E. Time required by the boys in O.E. was about double that of the N.E. The correction of the examination is also easier and more rapid.

18. The chance factor in selective type of intelligence tests.

S. V. SRINIVASA RAO, Mysore.

Selective type of intelligence tests is universally preferred to the inventive type because of the ease of correction. But as reported by Dr. Gopalaswami at the Science Congress, 1926, the selective type gives room for the play of chance elements or guess-work. This is specially so in the case of children and in the crucial tests in the case of adults. As a sort of compromise between the selective and the inventive types a new form was introduced which involved for a correct answer a *triple* choice amongst three alternatives, e.g. :—

What is absurd in—'Thank God, I am an atheist' said a socialist orator once. (Indicate your answer by underlining the suitable words in the following statement).

	a scientist	thank	Rupee.
If he is a	Christian	he need	not doubt
	an atheist	believe	the almighty
			God.
			idols.

There are 27 possible combinations here and it will not be possible to return the correct answer by mere guess-work. The absurdities test was put in two forms—(a) with 4 alternative answers (traditional type), (b) with 27 possible answers as described above (new form). The correlation co-efficients of reliability were calculated for the two types of tests.

Co-efficient of reliability	Traditional Type	New Form	while the
	$r=0.472$	$r=0.753$	

new form of the test appears to be superior to the traditional type, there is need for still further modifications so as to bring the co-efficient of reliability to about 0.95.

19. Relative values of the different sub-tests constituting the group tests of intelligence.

N. CHOUDHURY and N. CHAKRAVERTY, Dacca.

The value of group tests of intelligence as a whole were discussed in the paper communicated to the last session of the Congress by Dr. West and Mr. Dutta. The object of the present investigation was to find the relative value of the several sub-tests considered singly. The results of the Thorndike tests of intelligence (adapted) and applied to the students of the Teachers' Training College, Dacca, and the university results for three successive years were used as data for this investigation. The correlations of each individual test with the composite test as well as the university test were computed. The distribution of the scores was also examined. It was found that the values of the single tests vary widely. Test No. 3 (arithmetical processes) was almost useless, tests No. 2 (mixed sentences T.E), 6 (opposites) and 13 (drawing conclusions) were of comparatively little value, while tests No. 1 (direction), 5 (information), 2 (best answer), 9 (analogy) and 8 (number series) were found consistently satisfactory, yielding correlations between 0.20 to 0.57. The distribution of the scores in these cases conformed largely to the normal frequency curve. The proper weighting of the tests also was examined by the method of multiple correlation. It was found that the weighting could be greatly improved. Thus to get the best result if test No. 9 be credited with 20 marks (which is actually given to the test) test 5 should have 12 marks instead of 10 marks. If test 7 be credited with 5 marks then test 5 should have 4 marks instead of 10 marks.

20. Action-responses of elephants to verbal signs.

G. H. HANUMANTHA RAO, Mysore.

The paper reports a study of the action-responses of three elephants Sundra Gaj, Tara Rani, and Jang Bahadur, belonging to His Highness the Maharaja of Mysore. The elephants respond correctly to the following words (in Hindustani)—

- (a) Sit, Stand, Turn, Walk, Run, Move-to-side, Go-on, Come-here, Stop,
- (b) Salute, Lift, Pull, Chase, Break-branches, Beat, Bend, Wave-fan, Attack, Don't-move, Eat, Drink,
- (c) Don't-do-it, Wait, Take-more, Pull-all-together, Pull-lower-branch, Pull-higher-branch,
- (d) Slow, Fast,
- (e) 'I-will-punish-you'

The paper deals with the methods of teaching these words, the order in which they are learnt, and the possibilities of teaching new words.

21. A statistical study of the factors affecting the results of the B.T. examination.

TARANATH BHATTACHARYA, Dacca.

The object of the study was to find the intercorrelations between: (a) university results, (b) college record, (c) general intelligence, (d) study habits, (e) academic career, and (f) teaching experience and also to ascertain to what extent it is possible to predict university success from a knowledge of these factors. The materials used were seventeen B.T. students of the Teachers' Training College, Dacca. All these students resided in the same building of the hostel. General intelligence was found from the results of group tests of intelligence and the independent ratings of fellow students. Study habits were ascertained by averaging the

independent opinions of three friends who had closely observed them throughout the session.

Study habits were found to have almost no correlation with university success. Academic career and general intelligence had each a correlation of about 0.6 with university success. The correlation between study habits and general intelligence and that between teaching experience and university success came out negative. The latter may be due to the fact that there were a few young fresh graduates with high academic distinction in the list. Though the number of cases is small the figures are suggestive and further investigations are being undertaken.

22. Features that help to draw attention in newspaper advertisements.

N. S. NARAYANA SASTRY, Mysore.

The paper records the results of an experimental investigation of the effective features in newspaper advertisements. A random selection of advertisement sheets from various daily papers was used for the purpose. 35 college students served as the subjects. Each sheet of advertisement was exposed for 2 seconds and subjects were asked to note down immediately after any three of the advertisements that caught their eyes. The effectiveness of each advertisement was judged from the number of times it was noted by the whole group. The features employed in the successful and the unsuccessful advertisements were then analysed. An advertisement was considered as *successful* if 75% or more of the subjects mentioned it, and unsuccessful if 25% or less mentioned it. Judged by this standard it was found that the more effective features are in their order of preference (a) contrast, (b) illustrations, (c) large types, (d) position on the page, (e) area.

It was found that none of these features by themselves were very effective; but a combination of these features is always successful. It is also interesting to note that *mere area* unsupported by other features is the least successful, and that *contrast* between matter and background is more effective than even illustrations. The current belief that *mere area* and *illustrations* are amongst the most effective features does not appear to find support. It might also be mentioned that securing *contrast* in advertisements is less costly than *area* and *illustrations*.

23. A scale for measuring Bengali handwriting in primary schools.

ASWINI KUMAR DATTA, Dacca.

1643 specimens of writing were collected under standardised conditions from the primary schools of Eastern and Northern Bengal. These were rated according to quality by thirty competent judges and were then graded according to their combined judgments. From the whole series thus graded nine specimens were extracted representing nine degrees of quality separated by equal steps of merit. These nine specimens were then made into a scale. It is possible, by the use of this scale, for any person to make a judgment about handwriting which should remain unaltered on successive occasions and to express this judgment in a form intelligible to all persons who are acquainted with the scale.

The speed of writing was measured at its maximum. The average number of letters written per minute and the standard deviations were computed for each class. The average number of letters per minute were 11, 17, 24, 30 and 39 for classes I, II, III, IV, and V respectively.

The median specimens, one for each class of the primary schools, constitute another scale with the help of which it is possible to express the quality of any specimen in terms of the class norm.

24. Some conditions affecting performance in the winking glass test.

K. G. RAMA RAO, Mysore.

As the winking reflex is strongly established in all persons very soon after birth, the ability to control it might possibly be made an index of 'will,' in the sense of, the *power to inhibit* original tendencies react. The winking glass test is designed to measure the ability to inhibit the winking reflex. But the test requires standardisation. The present paper is an attempt at determining the conditions which render the inhibition of the reflex difficult. They are, (a) sufficient *contrast* between the background and the moving object, (b) movement of the object from an unexpected direction, (c) proximity of the eyes to the glass plate, (d) keeping both eyes open, (e) movement of the object from the marginal to the focal field of vision, and (f) fixation of a near object.

The test was given to a large number of normal persons and to criminals and juvenile delinquents in the Bangalore Central Jail. The results show clear group differences as between the normal and criminals, between adults and juveniles, between normals and confirmed alcoholics, and between persons convicted for impulsive offences and deliberate offences.

It requires further experimentation and standardisation to make the test an instrument capable of revealing *individual* differences in the capacity to inhibit tendencies to action.

25. On the waste involved in postponing the fixing of meaningful associations.

S. C. GHOSHAL, Jubbalpore.

The paper reports a measurement of the difference between the times taken for learning just after the meaning of a poem is imparted and that of memorising after some lapse of time. Shelley's poem 'The Fugitive' was used for this purpose. Two groups of 4 students each of the pre-matric class served as subjects.

Experiment I.—The story was narrated and the meaning of the stanza to be memorised was given to both the groups before learning. The average learning time was for

Group A 6',15.5"
Group B 5',37.5"

Experiment II.—After a lapse of one day the two groups was asked to memorise another stanza; but this time Group 'B' alone were told the meaning of the whole poem and of the stanza. The average learning time was

Group A 11',14.75"
Group B 6',57.5"

Percentage of waste of time for Group A—45.2%

Experiment III.—Similar in all respects to Experiment II, except for the fact that the lapse of time from the first experiment was 4 days. The average time of learning was

Group A 7',21"
Group B 4',23.5"

Group A required 50.4% more time on the fourth day owing to the break up of meaning.

To avoid a large wastage of time and of effort, it is necessary that the material should be learnt thoroughly soon after the meaning is imparted, and not postponed to subsequent days. Much the larger portion of the break up of associations take place in the course of the first day itself.

26. Vocational guidance of the blind and of the deaf-mute.

N. S. NARAYANA SASTRY, Mysore.

This is a report of the tests conducted in the Central Institute for Defectives, Mysore. The following intelligence tests were given to the Deaf-mutes with a view to suggesting readjustments in their vocational training—finger maze test, the picture completion test, Goddard's and Link's form board tests and the picture absurdities test. The pupils were found to fall into 7 groups on the basis of intelligence tests. The available occupations were graded on the basis of their supposed 'minimum intelligence requirements.' The pupils belonging to the various levels of 'Intelligence' were assigned to the several grades of occupations.

In the Blind section the following tests were employed—Seashore's pitch discrimination test, absurdities test, the opposites test, and the analogies test. The intelligence tests were all given orally. The pitch discrimination test revealed that judged by Seashore's standards only 8 out of the 32 blind pupils were fit for musical training. A discontinuance of the present practice of giving musical instruction to all the blind pupils compulsorily was suggested. For those that have not the basic abilities for learning music, other occupations such as rattan work and spinning were suggested.

27. Psychogalvanic response in sense-stimulation.

D. N. SEN, Patna.

My attention was drawn to the phenomena of galvanic response by the experiments of Sir Jagadis Bose which demonstrated that variations of resistance as well as of potential difference occurred in plants stimulated in various ways, by electric shocks, drugs, mechanical injuries, etc. I reproduced these experiments and was deeply impressed by the success obtained. The thought then came to me that the human subject also may be treated in a similar way by being placed in galvanometric circuit. I was surprised to find that the response was similar. This opened out to me a very promising field of investigation. The first series of these experiments were started last year and have been continued this year. The human body behaves like a plant placed in galvanometric circuit and shows measurable variations under stimulation. I gave up the resistance method when I found that by appropriate experimental arrangements a current could be had from the body itself and its variations under stimulation could be measured. The fatigue curves thus obtained, though showing changes with different subjects and under different kinds and intensities of stimulation, took, on the average, about 14 minutes to complete, *i.e.*, from the starting zero to the finishing zero. Another reason why I gave up the resistance method was that it was extremely difficult to secure a steady current from a source outside the body. I may mention here that curves of fatigue obtained from twigs and from human bodies had important similarities in form, though the latter were less stable than the former. The plant curves showed regular pauses demonstrating that in transmission the current suffered systematic resistance from plant tissue.

28. The Arcot experiments with intelligence tests.

MASON OLCOTT, Arcot.

The Arcot Mission and Arcot Assembly have been experimenting since 1922 with intelligence tests as a method of selecting children for boarding hostels. The tests were adapted from various American intelligence tests. They were frequently changed on the ground of their value. Scientific techniques were used to make the results as significant and

reliable as possible. They were printed in two booklets, verbal and non-verbal.

In order to evaluate the separate tests, their correlations with the total score, chronological age, intelligence quotient, and other tests were determined. These four correlations were used as criteria. These single criteria were then combined in various ways and the combinations were found which best evaluated the separate tests.

29. Estimation of visual angles.

MANINDRANATH SAMANTA, Calcutta.

The paper presents a series of experiments on the estimation of angles. Visual angles are judged in terms of lines forming them and in terms of the space enclosed. An attempt is made to compare the data under both of these conditions. The author also tries to exhibit the influence of the subjective conditions upon estimation.

30. Auto- and hetero-suggestion in hypnosis.

S. SANKARA MENON, Trivandrum.

The paper is a continuation of the paper on "Psychological Anesthesia" read and demonstrated at Calcutta during the fifteenth Sessions of the Indian Science Congress and describes two experiments in which hypnosis is induced by hetero-suggestive methods discussed therein. In the first experiment where an unwilling person is subjected to hypnosis, muscular catalepsy is observed and the person reported that he remained conscious of everything that passed round him. The subject of the 2nd experiment is a willing subject and in this case normal sleep is induced. From these two experiments the author concludes (1) that where the operator is the suggestive cause, the resulting effect arises from two causes: the first being the forces underlying the suggestion of the operator, the second being the resistive forces underlying the auto-suggestion of the subject. In the case of an unwilling subject the resulting effect is not really a case of anesthesia wherein the subject is completely unconscious but it is one of muscular catalepsy. Where the subject remains conscious of everything that takes place around him but without control over his external organs, the condition of the subject is hyper-normal as contrasted with dream which is a sub-normal one.

31. A conversion phenomenon in the life of dramatist Girish Chandra Ghosh.

SARASI LAL SARKAR.

The phenomenon of conversion in the life of dramatist Girish Chandra Ghosh has been studied with the view to find out whether some insight can be obtained regarding the unconscious activities connected with the phenomenon with the help of some of the researches of Dr. Freud. Girish Chandra who was at first only a very successful actor in the theatre, became a great dramatist, after a vision, in which he felt the presence of the Goddess Kali. The writer tries to explain the phenomenon with the help of certain researches of Dr. Freud concerning the unconscious activities of the super-ego.

32. Sadistic expressions.

H. D. BHATTACHARYYA, Dacca.

Some everyday sadistic phenomena are recorded in this paper.

33. Monocular estimation of short distances.

MANMATHA NATH BANERJEE, Calcutta.

Based on the data of experiments on 18 subjects, for both eyes for the distances of 5, 10 and 25 cms. vertical and horizontal, indicated by end points or lines; fixation shifting from the ends to the mid points. Estimation of the smallest distance is liable to greater error while the longest has been always underestimated. The left eye is more accurate for this distance. The perception of distance is more effective in the horizontal than in the vertical. Interesting results have been obtained for the factors of fixation and filling or non-filling.

34. A preliminary note on the technique of Psychogalvanic Reflex.

MANMATHA NATH BANERJEE, Calcutta.

Suggesting the ultimate use of resistance units for accurate scientific measurements instead of giving deflections of galvanometers only and an easy method of calculating the resistances. Consideration of the factors of varying electrical potential and thermo-electrical conditions of body areas. The desirability or otherwise of the inclusion of a battery in the circuit. The practical significance of the area in contact discussed. The efficiency of galvanic index and the thermopile in the measurement of emotion.

35. The competitive jealousy of a youth.

J. K. SARKAR, Muzaffarpur.

This paper shows how the idea of the superior status and of the recent marriage of the eldest brother gave rise to the accentuated form of jealousy in a youth. Besides, his over-anxiety about his brother was but a reaction to his own unconscious hostility towards the latter.

The interpretation of the dreams of the subject and the free associations given by him corroborate the above fact.

The maintenance of the subject's jealousy and hatred against his rival was made possible first by parent-identification, and subsequently by gradual disappearance of all his own loved objects.

In fine, the competitive jealousy of the youth manifested itself through anxiety-symptoms, and was built up of the painful idea of yielding the primary object—love to the secondary one, and of receiving the self-inflicted narcissistic wound.

36. A scientific approach to student strikes.

G. S. KRISHNAYYA, Mysore.

Introduction.—Scientific approach—free from concern with any particular instance.

Causes and occurrence.—Seen from a psychological and sociological point of view.

Prevention.—Psychological and sociological approach resulting in educational methods, measures and activities.

Treatment.—Scientific approach and its requirements.

Conclusion.—Need for dispassionate study and approach and sympathetic understanding.

37. "Stimulus error" in the determination of D.L. for lifted weights.

GOPESWAR PAL, Calcutta.

Consideration of Ticheners distinction between 'Process attitude' and 'Stimulus attitude' in judging sensory qualities and his interpretation of the discrepancy of the results of some of the Psychophysical experiments. Lengthy investigation carried out in the Calcutta Psychological Laboratory, extending over a period of two years, to verify the assumption underlying the interpretation. The assumption not corroborated by the experimental results and hence sense of the technical term "Stimulus Error" needs modification.

38. Diurnal course of efficiency.

H. P. MAITY, Calcutta.

The paper reports the results of a preliminary investigation on variations in voluntary muscular effort, reaction time and memorisation of nonsense syllables at three different periods of the day. The periods chosen are morning, afternoon and late evening. Effect of general fatigue on the physical and mental functions studied is indicated.

39. An experiment in education in Bengal, the Dalton plan.

G. BHATTACHARYA, Dacca.

The Dalton Laboratory Plan, whatever its defects, is a destructive criticism of the traditional method of giving a lesson "by talk and chalk." The six-lessons-per-diem time-table which is now followed in institutions is a wonderful part of a modern school machinery paralleled in precision only by a railway time-table showing the hours at which trains are timed to reach the stations. This is justified as a safeguard against waste of time in the hands of unskilled and incompetent teachers. But this advantage is more than counterbalanced by the preponderance of oral teaching by teachers and absence of opportunities on the part of pupils to learn to work for themselves. This is a serious defect of the existing system as it contributes very little to the development of character—the true aim of education.

General Discussion at the Science Congress.

MATHEMATICS AND LIFE.

Intellectual Discipline.

Mr. John Maclean, (Wilson College, Bombay) opened the discussion on the subject. In the course of his address he said that it was admitted already that the services of mathematics were invaluable in solving certain practical problems and in providing an intellectual discipline for those who could follow it and even occasionally in affording a means of diversion. But it was not sufficiently recognised that mathematics even in its elementary methods had a flexibility and a range of applicability that would make it of great help in steadying the gaze of many who were perplexed by elusive problems in business, in science and in all practical affairs and even of those whose interest centred round philosophy.

Mr. Banerjea of Calcutta dwelt upon the difficulty in teaching psychology to students who had no mathematical training.

Mr. Laxmana Iyer of Saidapet said that even in the Engineering College the students lacked efficient knowledge in the use of slide scales.

Mr. A. K. Dutt of Dacca, pointed out that in the schools at present a lot of useless mathematics was taught and that more efficient mathematics *i.e.*, useful to life problems should be introduced.

Mr. A. V. Krishnaswami of Chidambaram did not agree with the previous speaker that the mathematics taught in the schools was inefficient and he agreed with the lecturer that mathematics taught in the Colleges needs to be brought into relation with life.

Mr. A. A. Krishnaswamy Ayyangar of Mysore gave several instances as to how teaching of Mathematics in colleges might be made more vital.

Dr. Chakko of the Engineering College, agreed with the contention of Mr. Lakshmana Iyer that the Engineering students did not have sufficient mathematical equipment and that it was desirable to introduce the use of the slide scale earlier than it was done at present.

The Chairman in his concluding remarks said that mathematics was most essential to the growth of every science. In fact it had been said and rightly too that knowledge became scientific knowledge only when it was made amenable to mathematical treatment. Now there was a great deal of orientation towards the mathematical treatment of every subject.

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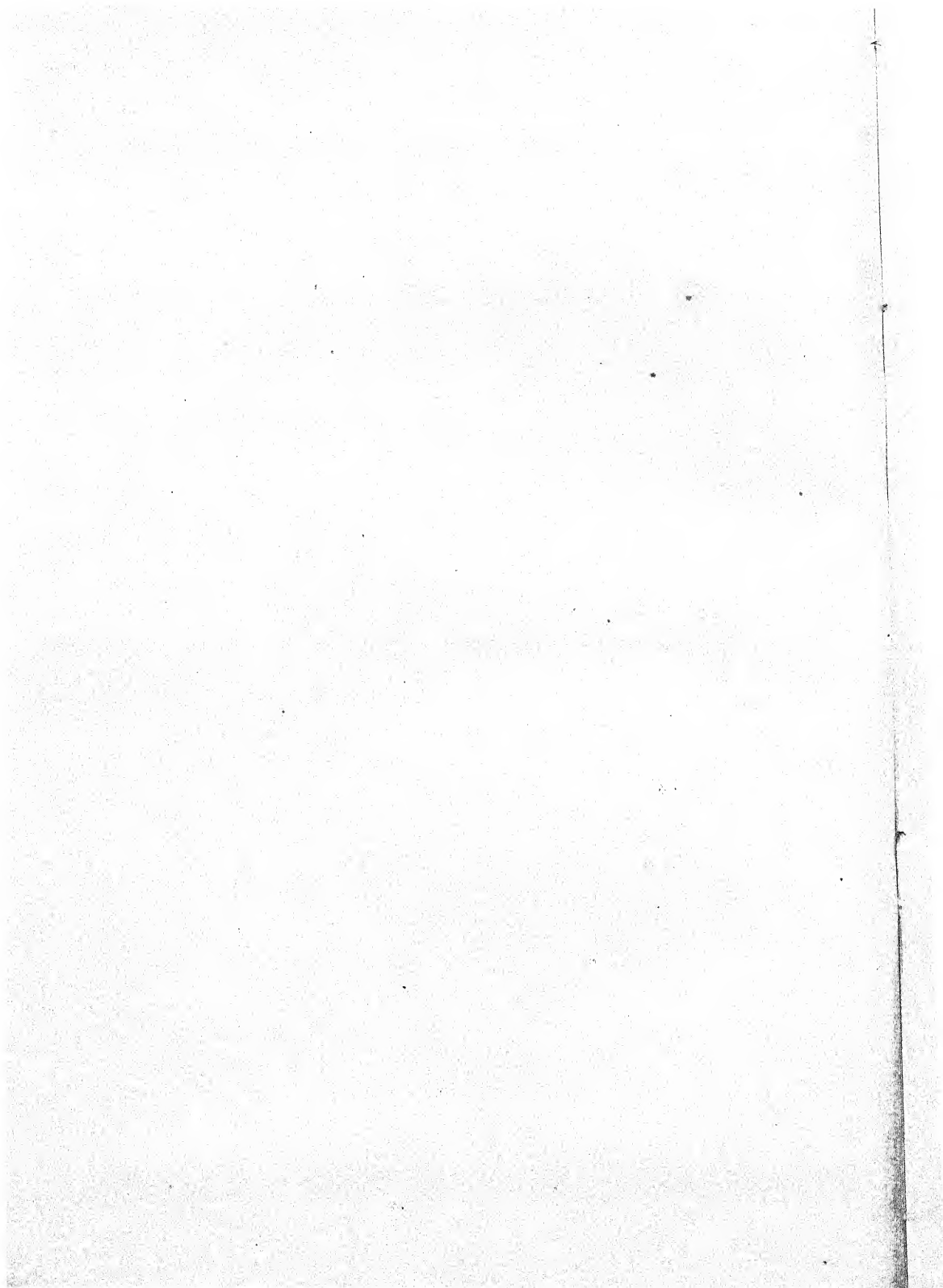
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*Anstead, R. D., M.A., Director of Agriculture, Chepauk, Madras.
*Asana, J. J., Gujarat College, Ahmedabad, Bombay Presidency.
*Ayyangar, A. A. Krishnaswami, 1043, Nanjarajagrahar, Mysore.
*Ayyangar, G. N. Rangaswami, Government Millets Specialist, Agricultural Research Institute, Lawley Road, Coimbatore, S.I.
Ayyangar, K.R.K., Captain, I.M.S.,

Pasteur Institute, Coonoor, S. India.

- Ayyar, C. S. Ram, Agricultural Research Institute, Pusa, Bihar.
*Ayyar, C. V. Ramaswami, Indian Institute of Science, Bangalore, S. India.
Ayyar, N. Ramaswami, Professor, American College, 30, Naicker New Street, Madras.
*Ayyar, P. Ramaswami, Assistant Chemist, Indian Institute of Science, Bangalore.
Ayyar, V. Ramaswami, M.A., Retired Deputy Collector, Chittoor, S. India.
*Azizullah, Mahommed, Khan Bahadur, Chemical Examiner's Office, Park Town, Madras.

B

- *Bal, D. V., Agricultural Research Institute, Nagpur.
Banerjee, Durgadas, University College of Science, 92, Upper Circular Road, Calcutta.
Banerjee, Kanti Gopal, M.Sc., Professor of Botany, Presidency College, Calcutta.
*Banerjee, Monmathnath, Psychology Department, 92, Upper Circular Road, Calcutta.
*Banerji, Bholanath, Pasteur Institute, Coonoor.
*Banerji, Niant Dhan, c/o. S. N. Banerji, Esq., Superintendent of Police (Retd.), 28, Model House, Lucknow.
*Banerji, S. C., 30, Shastitala Road, Narkeldanga, Calcutta.
*Banerji, S. K., The Observatory, Colaba, Bombay.
Barnes, Edward, Professor of Chemistry, Christian College, Madras.
*Barretto, F., Officer-in-Charge, Public Health Laboratory, Poona.

*Basu, P. N., Capt., I.M.S., Professor of Pathology, Medical College, Madras.

Basu, U. P., 52-2-A, Sukea Street, Calcutta.

Bengal Vaccine Laboratory, 2, Convent Lane, Entally, Calcutta.

Bhadkamkar, R. H., M.A., M.D., Empire Building, Fort, Bombay.

Bhaduri, Jnanendra Lal, 35, Ballygunge Circular Road, Calcutta.

Bhalerao, G. D., Helminthologist, I.I.V.R., Muktesar, P.O. Ritani, U.P.

*Bhatia, B. L., M.Sc., F.Z.S., Principal, Government College, Hoshiarpur, Punjab.

Bhatia, D., Lecturer in Zoology, University College, Colombo, Ceylon.

*Bhatia, S. L., Capt., I.M.S., Professor of Physiology and Dean, Grant Medical College, Bombay.

*Bhatnagar, S. S., D.Sc., University Professor of Chemistry, Lahore.

Bhattacharjee, S. P., School of Tropical medicine, Central Avenue, Calcutta.

*Bhattacharya, D. K., Professor of Physics, Science College, Patna.

*Bhattacharya, D. R., M.Sc., D.Sc., 8, George Town, Allahabad.

Bhattacharya, G., Manager, Adair Dutt & Co., Ltd., Post Box 2009, Calcutta.

*Bhattacharya, H. D., Department of Philosophy, Dacca University, P. O. Ramna, Dacca.

*Biswas, Kalipada, M.A., Curator of the Herbarium, Royal Botanic Garden, Near Calcutta.

Biswas, Sarat Lal, 4, Duff Lane, Calcutta.

*Blatter, Rev. E., S. J., Panchgani, via Bombay.

*Bose, N. K., Mathematical Officer, Irrigation Research Laboratory, Lahore.

*Bose, S. N., Professor of Physics, Dacca University, Dacca.

*Bose, S. R., D.Sc., F.R.S.E., Professor of Botany, Carmichael Medical College, Calcutta.

*Brahmachari, B. B., Asst. Director of Public Health, Bengal, Writers' Buildings, Calcutta.

*Brahmachari, U. N., Rai Bahadur, M.A., M.D., Ph.D., 82/3, Cornwallis Street, Calcutta.

Brooks, A. P., Agricultural Institute, Allahabad.

*Brühl, P. J., I.S.O., D.Sc., 1-A, Convent Road, Bangalore.

C

*Caius, Rev. J. F., S. J., St. Xavier's College, Cruickshank Road, Bombay.

Catterson-Smith, J. K., Indian Institute of Science, Bangalore.

Chakko, K. C., M.A., College of Engineering, Guindy, Saidapet Post, Madras.

*Chakladar, Haran Chandra, M.A., 28/4, Srimohan Lane, P.O. Kalighat, Calcutta.

Chakravarti, Gopal Chandra, D.Sc., P. R. S., Indian Institute of Science, Bangalore.

Chakravarti, N. G., Department of Chemistry, Presidency College, Calcutta.

Chakravorthy, A., Professor of Philosophy, Presidency College, Madras.

Champion, H., College House, Saidapet, Madras.

Chandrasekhar, S., Chandra Vilas, Edward Elliott Road, Mylapore, Madras.

Chandy, C. C., B.A. (c/o. Messrs. Adair Dutt & Co., Ltd.), Kaleeli Mansion, Mount Road, Madras.

Charan, S., M.A., M.Sc. (London), Professor of Mathematics, Agra College, Agra, U.P.

Chatterjee, N. K., Asst. Analyst, Public Health Laboratory, Bengal, School of Tropical Medicine, Calcutta.

Chatterjee, N. N., Lecturer, Calcutta University, Aerial Lodge, 18, Mirzapur Street, Calcutta.

*Chatterjee, A. C., D.Sc., Chemistry Department, Lucknow University, Lucknow.

*Chatterjee, Devendra Nath, Chemical Examiner to the Governments of U. P. and C. P., Agra.

*Chauduri, H., M.A., Ph.D., Punjab University, Lahore.

Cherian, P. V., General Hospital, Madras.

Chettiar, T. A. Ramalingom, Rao Bahadur, B.A., B.L., Race Course Road, Coimbatore, S. India.

*Chhibber, H. L., M.Sc., F.G.S.,

- F.R.G.S., 230, Dalhousie St., Rangoon.
- *Chopra, B. N., Zoological Survey of India, Indian Museum, Calcutta.
- *Chopra, R. N., Lt.-Col., I.M.S., Department of Pharmacology, School of Tropical Medicine, Calcutta.
- Chowdhury, J. K., Chemical Laboratory, Dacca University, P.O. Ramna, Dacca.
- *Chukravarty, B. N., D.Sc., 92, Upper Circular Road, Calcutta.
- *Cooper, Hugh, Pathologist, Imperial Institute of Veterinary Research, Muktesar, P.O. Ritani, U.P.
- *Cruickshank, J. A., Major, I.M.S. (retd.), Office of the Chief Medical Officer, Park Town, Madras.
- Deshpande, D. Damodar, Indian Institute of Science, Hebbal, Bangalore.
- *Deshpande, S. S., Professor of Chemistry, Holkar College, Indore, C.I.
- Dey, B. B., D.Sc., 92, Upper Circular Road, Calcutta.
- Dey, Debakar, Rai Sahib, Asst. Principal, Bengal Veterinary College, Calcutta.
- *Dhavale, B. B., M.A., A.I.C., Bengal Tanning Institute, Pagladanga, P.O. Entally, Calcutta.
- D'Souza, A. J., Major, I.M.S., Resident Medical Officer, General Hospital, Madras.
- *Dudgeon, Winfield, Ewing Christian College, Allahabad.
- *Dunncliff, H. B., M.A., Sc.D., F.I.C., Special Chemical Adviser, Central Board of Revenue (Customs), Custom House, Calcutta.
- *Dutta, R. L., D.Sc., F.C.S., F.R.S.E., Industrial Chemist, Government of Bengal, 40-1-A, Free School Street, Calcutta.
- Dutt, S. B., D.Sc. (London), Reader in Chemistry, The University, Allahabad.

D

- *Das, Anandakishore, Professor of Chemistry, Cotton College, Gauhati, Assam.
- *Das, B. K., Professor of Zoology, 35, Ballygunge Circular Road, Ballygunge, Calcutta.
- *Das, B. M., Superintendent, Bengal Tanning Institute, P.O. Entally, Calcutta.
- *Das-Gupta, H. C., M.A., F.G.S., Professor, Presidency College, 60-A, Chakrabere Road North, Calcutta.
- *Dastur, R. H., Professor of Botany, Royal Institute of Science, Fort, Bombay.
- Datta, A. K., Professor, 26, Training College Road, Dacca.
- Datta, Bhupendra Nath, 3, Gour Mohan Mukherjee Street, Calcutta.
- *Datta, H. N., Ayodhya Koti, Marris Road, Aligarh.
- Datta, Mrs. Sarojini, Professor of Botany, Bethune College, 181, Cornwallis Street, Calcutta.
- Datta, Snehamay, 6, Dover Lane, Ballygunge, Calcutta.
- David, J. C., M.B.B.S., Professor of Pharmacology, Medical College, Madras.
- De, J. C., M.A. (London), Lecturer, University College, Colombo, Ceylon.
- *Deolalkar, T. K., Karnatak College, Dharwar.

E

- Epps, Miss P. V. L., M.B.B.S. (London), Missionary Medical School for Women, Vellore, N. Arcot, S. India.
- *Ezekiel, M., Professor, Wilson College, Chaupatty, Bombay.

F

- Faruqi, A. J., Muslim University, Aligarh.
- *Fawkes, Mrs. A. K., 1, Sultanpur Road, Lucknow.
- *Fermor, L. L., D.Sc., Geological Survey of India, Indian Museum, Calcutta.
- Ferrol, Rev. D., S. J., D.Sc., St. Aloysius, College, P.O. Kodialbail, Mangalore.
- *Forster, M. O., D.Sc., F.R.S., Indian Institute of Science, P.O. Hebbal, Bangalore.
- *Fowler, Gilbert J., Agricultural Gardens, Nawabganj, Cawnpore.
- *Fox, Cyril S., Geological Survey of India, Indian Museum, Calcutta.

- *Fraser, J. C., Lt.-Col., I.M.S.,
"Florican," Malabar, Calicut.
*Fyson, P. F., I.E.S., Presidency
College, Madras.

G

- *Ganguli, P. B., Science College,
Patna.
Ganguli, Sarada Kanta, Revenshaw
College, Cuttack.
*Garu, A. V. Bhashyam Reddi,
Landholder, Cuddalore.
*Gharpure, P. V., 2, Garden Lane,
Sandhurst Road, Bombay.
*Ghose, S. L., Lecturer in Botany,
Government College, Lahore.
*Ghosh, Ekendranath, M.Sc., M.B.,
66, Cornwallis Street, Calcutta.
*Ghosh, H. N., M.B. (Cal.), 41,
Dhurumtalla Street, Calcutta.
Ghosh, J., M.A., Ph.D., 19, Bakshi-
bazar Road, Dacca, Bengal.
*Ghosh, P. N., 92, Upper Circular
Road, Calcutta.
*Ghoshal, S. C., Professor, Spence
Training College, Jubbulpore.
Gideon, P. W., Karnatak College,
Dharwar.
Gnanathu, Rev. G., London Mis-
sion, Erode, Madras Presidency.
Godbole, S. N., College of Science,
Nagpur.
Gokhale, A. G., M.A., B.Sc., A.I.C.,
A.I.I.Sc., Government Central
Distillery, Nasik Road, G.I.P.
*Gokhale, J. G., Khandesh Educa-
tion Society, Amalner, Khan-
desh.
*Gopalaswami, M. V., Professor,
Maharajah's College, Mysore.
Gordhandas Desai & Co., 204,
Hornby Road, Bombay.
*Gore, S. N., Assistant Director,
Haffkine Institute, Parel, Bom-
bay.
*Gosling, Geo. W., c/o. Messrs.
Adair Dutt & Co., Ltd., 5, Dal-
housie Square, Calcutta.
*Goswami, Mahendra Nath, M.A.,
D.Sc., University College of
Science, 92, Upper Circular Road,
Calcutta.
Gowda, A. C. Dave, College Hos-
tel, Mysore.
*Gravely, F. H., D.Sc., Museum
House, Egmore, Madras.
*Guha, B. S., M.A., Ph.D., c/o.
Zoological Survey of India,
Indian Museum, Calcutta.

Guha, P. C., Indian Institute of
Science, Bangalore.

*Gupta, B. M., M.Sc., Ph.D., Read-
er, Lucknow University, Luck-
now.

Guthrie, A., Leather Trades Insti-
tute, Washermanpet, Madras.

H

- Harper, A. E., Y.M.C.A., George
Town, Madras.
*Hasan, K. Habib, Government
Industrial Laboratory, Hydera-
bad, Deccan.
Hasan, Mohamed Mehdi, B.Sc.,
Indian Institute of Science, Ban-
galore.
Hesterlow, A. M. V., Capt., I.M.S.,
Professor of Hygiene, Hygiene
Laboratory, Medical College,
Madras.
Higginbotham, Sam, Principal,
Agricultural Institute. P.O.
Naini, Allahabad.
*Hill, Owen Berkeley, Lt.-Col.,
I.M.S., Superintendent, Euro-
pean Mental Hospital, Kanke,
Ranchi.
Hingston, C.A.F., Lt.-Col., I.M.S.,
Principal, Medical College, Ma-
dras.
*Hora, Sunder Lal, D.Sc., Indian
Museum, Calcutta.
*Howard, A., C.I.E., M.A., Direc-
tor, Institute of Plant Industry,
Indore & Agricultural Adviser
to States in C.I. & Rajputana,
Indore.
*Howard, Mrs. G.L.C., M.A., Sec-
ond Imperial Economic Bota-
nist, Institute of Plant Industry,
Indore.
Hulkoti, R. Y., Inspector of Agri-
cultural Schools, Poona.
*Husain, M. Afzal, Entomologist
to the Government of the Punjab,
Lyallpur.
Hussain, Syed, M.Sc., Ph.D.,
Professor of Chemistry, Osmania
University College, Hyderabad,
Deccan.

I

- Inamdar R. S., Hindu University,
Benares.
Iyengar, A. V. Varada Raja, Indian
Institute of Science, Bangalore.
*Iyengar, K. R. K., Capt., I.M.S.,

- Pasteur Institute, Coonoor, S. India.
- Iyengar, K. V. Srinivasa, "Venkatesa Vilas," Royapettah High Road, Royapettah, Madras.
- *Iyengar, M.O.P., M.A., Additional Professor of Botany, Presidency College, Madras.
- *Iyengar, M. O. T., Entomologist, Department of Public Health, Bengal, Writers' Buildings, Calcutta.
- Iyengar, M. Sesha, Superintendent, Intermediate College, Bangalore.
- Iyer, K. R. Narayana, B.A., Agricultural Bacteriologist to the Government of Travancore, Quilon, Travancore.
- *Iyer, L. K. A., Rao Bahadur, B.A., L.T., 1-5, Prem Chand Boral Street, Bowbazar, Calcutta.
- Iyer, M. Subramania, Hony. Physician, Government Maternity Hospital, 16, Cutcherry Road, Mylapore, Madras.
- *Iyer, M. Venkatrama, 2nd Road, Gairpur Extension, Basavangudi, Bangalore.
- Iyer, S. Ramakrishna, Professor, H.H. The Maharajah's College of Science, Trivandrum, Travancore.
- *Iyer, T. V. Ramakrishna, B.A., Ph.D., F.Z.S., Agricultural College, Coimbatore, S. India.
- *Kashyap, Shiv Ram, 11, Multan Road, Lahore, Punjab.
- *Kashyap, Mrs. S. R., 11, Multan Road, Lahore, Punjab.
- Kausalya, Miss G. K., Queen Mary's College, Mylapore, Madras.
- Khan, Inait Ali, Lecturer in Zoology, Muslim University, Aligarh.
- Khandwalla, M. T., Major, I.M.S., Superintendent, Central Jail, Cannanore, Malabar.
- *Khastgir, K. K., Professor, Government College, Chittagong.
- *Khastgir, S. R., D.Sc., University College, Colombo, Ceylon.
- Kichlu, P. K., Science College, Patna.
- King, H. H., M.B.B.S., Lt.Col., I.M.S., Director, King Institute, Guindy, Madras.
- *Kottur, G. L., Government Farm, Dharwar.
- *Krishna, S., Forest Bio-Chemist, Forest Research Institute & College, Dehra Dun.
- Krishnan, B. T., B.A., M.B.B.S., Professor of Physiology, Medical College, Madras.
- *Krishnan, M. S., c/o. Geological Survey of India, Indian Museum, Calcutta.
- *Krishnamurti, V., I.V.S., Professor of Pathology and Bacteriology, Madras Veterinary College, Madras.
- Krishnaswami, C. R., M.B.B.S., "Rama Bhavan," 100, Poona-mallee High Road, Vepery, Madras.
- Krishnaswami, G. V., Sri Meenakshi College, Chidambaram, Madras Presidency.
- Krishnaswamy, M. O., B.A., B.L., c/o. M. O. Parthasarathy Iyengar, Esq., Additional Professor of Botany, Presidency College, Chepauk, Madras.
- Krishnayya, G. S., M.A., Ph.D., Professor of Education, Mysore University, Mysore.
- Kshirsagar, K. A., B.A., S.T.C.D., Headmaster, Government Training School, Nasik.

J

- Jatkar, S. K. Kulkarni, Indian Institute of Science, Bangalore.
- Jesudas, J., Y.M.C.A., Martandam, Travancore.
- *Joshi, N. V., 1st Assistant, Bacteriological Section, Pusa, Bihar.

K

- Kalyanaraman, S., Assistant Professor of Physics, Presidency College, Madras.
- Kamath, M. L., B.A., M.D., Professor of Medicine, Medical College, Vizagapatam.
- *Kanga, D. D., Gujarat College, Ahmedabad.
- *Kanga, Miss P. M., 25, Nepean Sea Road, Malabar Hill, Bombay.
- Kappauna, A. N., Chemical Laboratory, University of Dacca, Ramna, Dacca.

L

- Labernadie, Major, Chief of Research Laboratory, Pondicherry.
- Lakshminarayan, C., Professor of

Zoology, Christian College, Madras.

Lakshmiopathi, A., B.A., M.B. & C.M., "Bishagratna," 43, Harris Road, P.B. 369, Mount Road, Madras.

Lal, Krishna Behari, M.Sc., Research Scholar in Zoology, The University, Allahabad.

Lamoureux, A., Lt.Col., Director, Medical College, Pondicherry.

*Law, Satya Churn, M.A., B.L., F.Z.S., 50, Kailas Bose Street, Calcutta.

*Limaye, D. B., Asst. Director, Ranade Institute, Poona.

Lorimer, A. P. G., Lt.Col., I.M.S., Medical College, Madras.

M

*MacCulloch, A. F., M.A., B.Sc., 50, Poonamallee High Road, Kilpauk, Madras.

*MacLean, John, U. F. C. Mission, Gowalia Tank Road, Bombay 7.

Mahan, Singh, Lecturer in Chemistry, Government College, Lahore.

*McMahon, P. S., Professor, Lucknow University, Lucknow.

Mahanti, P. C., 92, Upper Circular Road, Calcutta

Maheshwari, Panchanan, Research Scholar, Department of Botany, The University, Allahabad.

*Mahommed, Wali, M.A., Ph.D., Professor of Physics, The University, Lucknow.

*Majumder, G. P., M.Sc., Presidency College, Calcutta.

*Majumdar, S. K., 26, Chuckerbere Road, North, Elgin Road, Calcutta.

*Malcomson, G. E., Lt.Col., I.M.S., Physician, General Hospital, Madras.

Malone, R. H., Major, I.M.S., Director, Pasteur Institute, Kasauli.

*Manen, Johan van, General Secretary, Asiatic Society of Bengal, 1, Park Street, Calcutta.

Manjunath, B.L., B.A., M.Sc., D. Phil., Department of Chemistry, Central College, Bangalore.

*Mansuri, Q. A., Professor of Chemistry, Muslim University, Aligarh, U.P.

Masilamani, S.E.D., M.B.B.S., Isolation Hospital, Tondiarpet, Madras.

Mason, Miss E. D., Women's Christian College, College Road, Madras, S.W.

Mathur, K. K., Professor, Hindu University, Benares.

Mathur, S. B. L., Lecturer in Physics, Lucknow University, Lucknow.

Mazumdar, B. C., 33/3, Lansdowne Road, Calcutta.

*Mehra, H. R., M.Sc., Ph.D. (Cantab.), Reader in Zoology, University of Allahabad, Allahabad.

Mehta, Dev Raj, M.Sc., I.C.C.C., Research Scholar, Agricultural College, Lyallpur, Punjab.

*Mehta, K. C., M.Sc., Ph.D., Prof. of Botany, Agra College, Agra.

*Mehta, Miss Maneck Merwanji, 44, Lamington Road, Byculla, Bombay, S.

*Meldrum, A. N., Royal Institute of Science, Mayo Road, Bombay.

Menon, C. P. Viswanatha, 5, Gengu Reddi Street, Egmore, Madras.

*Menon, K. R., Vice-Chancellor, Madras University, Madras.

Menon, K. Rama, M.B., F.R.C.S., Assistant Surgeon, General Hospital, Madras.

Menon, P. Govinda, B.A., Conservator of Forests, Chalakkudy, Cochin State.

*Menon, S. Sankara, B.A., B.L., High Court Vakil, Trivandrum, South India.

Menon, T. Bhaskara, M.B., M.R.C.P., 24, Hunters Road, Vepery, Madras.

Menon, T. K., Honorary Physician, General Hospital, Madras.

Menon, T. K. Raman, M.D., D.T.M., 5, Gengu Reddi Street, Egmore, Madras.

*Mhaskar, K. S., M.D., Haffkine Institute, Bombay.

*Mitra, S. K., Economic Botanist, Assam, Jorhat, Assam.

Mitra, Subodh, M.D., F.R.C.S., 150, Russa Road, Calcutta.

Mitter, Julian H., Botany Department, Allahabad University, Allahabad, U.P.

*Mitter, P. C., D.Sc., 22, Garpar Road, Calcutta.

*Modi, J. J., 211, Pilot Bunder Road, Colaba, Bombay.

*Moghe, M.A., M.A., M.Sc., M.Z.S., Nagpur University, Nagpur.

*Mockerjee, Sir R. N., K.C.I.E.,

- K.C.V.O., 6-7, Clive Street, Calcutta.
- Moongilal, D. Agarwalla, 32, Perumal Mudali Street, Sowcarpet, Madras.
- *Moses, S. T., M.A., F.Z.S., F.R.A.I., Asst. Director of Fisheries, Madras.
- *Moudgill, K. L., M.A., D.Sc., F.I.C., H.H. The Maharaja's College of Science, Trivandrum, S. India.
- Mudaliar, M. R. Guruswami, Physician, General Hospital, Madras.
- *Mukerjee, Durgadas, Lecturer in Zoology, Calcutta University, 35, Ballygunge Circular Road, Calcutta.
- Mukherjee, S. K., M.Sc., D.Sc. (London), F.Z.S., Reader in Botany, Lucknow University, Lucknow.
- *Mukherjee, J. N., M.A., D.Sc., 92, Upper Circular Road, Calcutta.
- *Mukherjee, S. K., Physics Department, Dacca University, P.O. Ramna, Dacca.
- Mukherji, Ashutosh, Research Chemist, School of Tropical Medicine, Calcutta.
- Mukherji, S. K., Professor of Physics, Agra College, Agra.
- Muthu, C., M.D., 9, Monteith Road, Egmore, Madras.
- Muthuswami, T. N., College of Engineering, Guindy, Saidapet P.O., Madras.
- Narayanan, C., Professor, Medical College, Pondicherry.
- Nariman, R. K., M.I.C.E., F.R.G.S., Post Box No. 48, Bombay.
- Nayar, A. S. Mannady, Professor of Bio-Chemistry, Medical College, Madras.
- Nayar, K. Koman, L.R.C.P. & S., D.O.M.S., Ag. Superintendent, Government Ophthalmic Hospital, Madras.
- *Nayar, M. Raman, B.A., A.I.L.Sc., Lecturer in Chemistry, Lucknow University, Lucknow.
- Negi, P. S., M.Sc., Assistant Entomologist, Indian Lac Research Institute, P.O. Namkum, Ranchi (Behar).
- *Nehru, S. S., I.C.S., Rae Bareilly, U.P.
- *Neogi, P., Ph.D., I.E.S., Presidency College, Calcutta.
- Nepali, Rajvaidya A. N., The Radium Institute, 103/3, Lower Chitpore Road, Calcutta.
- Newcomb, Clive, Major, I.M.S., Pasteur Institute, Coonoor.
- Normand, A. R., Chemistry Department, Wilson College, Bombay No. 7.
- Normand, C. W. E., Meteorological Office, Poona.
- Noronha, Frank, M.B., C.M., D.P.M., Superintendent, Mental Hospital, Bangalore.
- *Norris, Roland V., D.Sc., F.I.C., Director, Tea Research Institute of Ceylon, Newara Eliya, Ceylon.
- N
- *Nag, N. C., 93, Upper Circular Road, Calcutta.
- Naidu, A. Srinivasalu, Medical College, Madras.
- Naidu, B. P. B., Haffkine Institute, Parel, Bombay.
- *Naik, K. G., Professor of Chemistry and Industrial Chemist to the Baroda Government, Baroda.
- Nair, K. Karunakaran, M.A., Professor of Zoology, Maharajah's College, Ernakulam, Cochin.
- *Narayan, A. L., M.A., D.Sc., Professor of Physics, Maharaja's College, Vizianagaram.
- Narayanamurti, D., Department of Bio-Chemistry, Indian Institute of Science, Hebbal, Bangalore.
- O
- Olcott, Mason, Vellore, North Arcot, Madras Presidency.
- P
- *Pai, M. Kesava, Rao Bahadur, M.D., 48, Harris Road, Mount Road, Madras.
- *Pandalai, K. G., Major, I.M.S., Surgeon, General Hospital, Madras.
- *Pandit, C. G., King Institute, Guindy, Madras.
- *Pandya, K. C., St. John's College, Bag Muzaffar, Agra.
- Pantulu, The Hon'ble Mr. V. Ramdas, Mylapore, Madras.
- *Paramanand, M. J., 217, Charni Road, Bombay.

*Parameswaran, H., Professor of Physics, Presidency College, Madras.

*Paranjpe, G. R., Professor, Royal Institute of Science, Bombay.

*Parija, P., I.E.S., Professor of Botany, Ravenshaw College, Cuttack.

Parker, R. N., Forest Botanist, Dehra Dun.

Patel, A. M., Wilson College, Chowpatty, Bombay.

*Patel, P. T., Medical Superintendent, Arthur Road Hospitals, Bombay 11.

Pattabhiramayya, P., M.A., Research Assistant, Dasannapet, Vizianagaram.

Patwardhan, V. N., Indian Institute of Science, Bangalore.

Pillai, M. S. Thayappa, District Board Office, Saidapet, Madras.

Pilley, C. K. Krishnaswami, Professor of Geology, Presidency College, Madras.

Prasad, Kamta, Professor of Physics, Science College, Patna.

*Prashad, Bani, D.Sc., F.R.S.E., Indian Museum, Calcutta.

Puri, A. N., Physical Chemist, Pusa.

R

Raghavan, M.D., B.A., M.R.A.S., F.R.A., Museum House, Egmore, Madras.

Raghavachari, T. N. S., B.A., Senior Bacteriological Assistant, King Institute, Guindy, Sri Venkatesa Vilas, Naidu Street, Mylapore, Madras.

*Rahman, Wahidur, B.Sc., Professor of Physics, Osmania University College, Hyderabad, Decan.

Raj, C. Simon Jeyasingh, G.B.V.C., Veterinary Assistant Surgeon, Reddi Polaveram, East Godavery.

*Raju, V. Govinda, Rao Bahadur, Superintendent, Bengal Vaccine Laboratory, 2, Convent Lane, Entally, Calcutta.

Ramachandran, S., Government Brennen College, Tellicherry, Malabar.

Ramakrishnan, S., Professor of Bacteriology, Medical College, Madras.

Ramakrishnan, T. S., Assistant Lecturer in Micrology, Agricultural College, Lawley Road P.O., Coimbatore.

*Raman, Sir C. Venkata, Kt., D.Sc., F.R.S., 210, Bowbazar Street, Calcutta.

*Ramanathan, K. R., Meteorological Office, Poona.

Ramanathan, V., Assistant Cotton Specialist, Kolpatti, Tinnevely District.

Ramanujachari, R., M.A., Chief Lecturer in Philosophy, Sri Minakshi College, Chidambaram, South Arcot.

*Ramanujam, S. G. Manavala, Professor of Zoology, Presidency College, Madras.

Rangaswami, M., Assistant Biochemist, Indian Lac Research Institute, P.O. Namkum, B. N. Ry.

Rao, B. Sanjiva, Indian Institute of Science, Bangalore, S. India.

*Rao, B. Sanjiva (Dr.), Professor of Chemistry, Central College, Bangalore.

*Rao, C. R. Narayana, Professor of Zoology, Central College, Bangalore.

*Rao, H. Srinivasa, Zoological Survey of India, Indian Museum Calcutta.

Rao, K. Umanatha, B.A., A.I.C., Mysore Iron Works, Bhadravati, Mysore State.

Rao, L. N., M.Sc., Assistant Professor, Bazar Street, Basavanagudi, Bangalore City.

Rao, M. Anandapadmanabha, Principal, Kumbakonam College, Kumbakonam.

Rao, M. A. Govinda, M.A., Ph.D. Indian Institute of Science Hebbal, Bangalore.

Rao, M. Vinayak, Rao Bahadur, Geological Survey of India, Indian Museum, Calcutta.

Rao, N. Mangesh, M.B., F.R.C.S., Surgeon, General Hospital, Madras.

Rao, N. S. Rama, T.S. Adyar, Madras.

Rao, Sethu Rama, M.A., F.G.S., Geological Survey of India, Indian Museum, Calcutta.

Rao, U. Krishna, M.B.E.S., 323, Thambu Chetty Street, G.T., Madras.

- Rao, The Hon'ble Mr. U. Rama, 323, Thambu Chetty Street, G.T., Madras.
- *Rao, V. Appa, Additional Professor of Physics, Presidency College, Triplicane, Madras.
- *Rao, Y. Ramachandra, Rao Sahib, M.A., F.E.S., Government Entomologist, Lawley Road, Coimbatore, S. India.
- Rau, K. Venkat, The Research Laboratory, Harris Road, Mount Road, Madras.
- *Ray, Bidhu Bhusan, D.Sc., Science College, 92, Upper Circular Road, Calcutta.
- *Ray, Kumar Sarat Kumar, 1/4, European Asylum Lane, Calcutta.
- Ray, R. C., Science College, Patna.
- *Ray, Satyendra Nath, B.A., M.Sc., 14-B, Hewett Road, Lucknow.
- Registrar, University of Rangoon, Rangoon.
- Roy, Hiralal, Bengal Technical Institute, Jadavpur, 24-Pergs.
- Roy, S. C., M.Sc., Chemistry Department, Isabella Thoburn College, Lucknow.
- *Roy, Sarat Chandra, Rai Bahadur, M.A., B.L., Editor, "Man in India," 18, Church Road, Ranchi.
- *Roy, S. K., Ph.D., Department of Geology, Indian School of Mines, Dhanbad.
- Roye, S. S., School of Agriculture, Bulandshahr, U.P.
- S
- *Sabnis, T. S., Agricultural College, Cawnpore.
- *Saha, Abinas Chandra, Professor, Rajshahi College, P.O. Ghoramara, Rajshahi.
- *Saha, Meghnad, D.Sc., F.R.S., Professor, The University, Allahabad.
- *Sambamurti, G., Lecturer in Chemistry, Government Arts College, Rajahmundry.
- *Sane, S. M., 6-A, Jopling Road, Lucknow.
- *Sarangdhar, V.N., M.A., B.Sc., D. Road East, 4, Northern Town, Jamshedpur, via Tatanagar, B. N. Ry.
- Sarathy, R. P., M.A., Statistical Assistant, Irrigation Research Laboratory, Lahore.
- *Sarkar, J. K., G.B.B. Government College, Muzaffarpur.
- Sarkar, P. B., D.Sc., University College of Science, 92, Upper Circular Road, Calcutta.
- *Sarkar, Sarasi Lal, Civil Surgeon, P.O. Sonarpur, Noakhali.
- *Sarma, R. Naga Raja, Assistant Professor, 2/8, Olagappa Chetty Street, Triplicane, Madras.
- Sarma, V. V., Lecturer in Science, Government Training College, Rajahmundry.
- Scientific Advance Co., 307, Linga Chetty Street, G.T., Madras.
- *Scientific Instruments Co., The, 1, Johnstonganj, Allahabad.
- Seethapathy, T., Assistant Director, King Institute, Guindy, Saidapet, Madras.
- *Sen, D. N., M.A., I.E.S., Principal, B. N. College, Patna.
- *Sen, H. K., Professor, University College of Science, 92, Upper Circular Road, Calcutta.
- *Sen, J. M., M.Ed., B.Sc., Second Inspector of Schools, Presidency Division, 1, Giris Vidyaratna Lane, Calcutta.
- *Sen, N. R., University College of Science, 92, Upper Circular Road, Calcutta.
- *Sen, R. N., Professor, Presidency College, Calcutta.
- *Seshaiya, R. V., Natural Science Assistant, S. M. D. H. School, Tirupati, S. India.
- Sethi, D. R., Director of Agriculture, South Bihar, Gaya.
- Sethi, R. L., Economic Botanist, Cawnpore, U.P.
- *Sewell, R. B. S., Lt.-Col., I.M.S., Zoological Survey of India, Indian Museum, Calcutta.
- Shah, N. M., Karnatak College, Dharwar.
- Shah, S. V., Professor of Chemistry, Rajaram College, Kolhapur.
- Shaha, Braja Bullav, 45-A, Sovabazar Street, Calcutta.
- *Sharif, M., M.Sc., Assistant Superintendent, Z.S.I., Indian Museum, Calcutta.
- *Sharma, L. C., Rao Bahadur, I.A.S., Deputy Director of Agriculture, Pratapgarh, Oudh.
- Sharma, Nandkishore, Rai Sahib, Deputy Director of Agriculture, Jhansi.

- *Sharma, R. K., S. D. College, Lahore.
- Shastri, N. Venkatanarayana, 599, Ramachandra Agrahar, Mysore.
- Shastri, P. D., M.A., Ph.D., B.Sc., I.E.S., Professor, Presidency College, Calcutta.
- *Shastri, T. P. Bhaskara, Nizamiah Observatory, Begumpet, N.G.S. Ry., Deccan.
- Simham, R. D. N., B.E., M.E., (Hon.), M.A.A.A.S., A.M.T.P.I., Personal Assistant to Director of Town Planning, 35, Mount Road, Madras.
- *Singh, Bawa Karkar, I.E.S., Professor of Chemistry, Ravenshaw College, Cuttack.
- Singh, T. C. N., Institute of Plant Industry, Indore.
- Sinha, B. N., Assistant Director of Agriculture, c/o. T. C. Singh, Esq., Institute of Plant Industry, Indore.
- *Sinha, Suhrid Chandra, Professor, 92, Upper Circular Road, Calcutta.
- *Sivan, M. R. Ramaswami, Rao Bahadur, Retired Principal, Agricultural College, Lawley Road, Coimbatore, S.I.
- Skinner, J. M., Lt. Col., I.M.S., General Hospital, Madras.
- *Smith, W. Erlam, I.E.S., Presidency College, Madras.
- *Sohoni, V. V., The Observatory, Alipur, Calcutta.
- Sokhey, S. S., Major, I.M.S., Haffkine Institute, Bombay.
- *Soparkar, M.B., M.D., Haffkine Institute, Parel, Bombay.
- Srinivasamurthi, G., B.A., M.B., C.M., Principal, Indian School of Medicine, Kilpauk, Madras.
- Srinivasan, E. V., M.B. & C.M., Mylapore, Madras.
- Srinivasaya, M., Department of Bio-Chemistry, Indian Institute of Science, Bangalore.
- Subbaiyar, A. S., B.A., Consulting Geologist, 3, Ekambarapuram, P.T., Madras.
- *Subrahmanyam, V., Lecturer in Bio-Chemistry, Indian Institute of Science, Hebbal, Bangalore.
- Subramaniam, V., Indian Institute of Science, Bangalore.
- *Subrahmanyam, S. G., 17, Akbar Saheb Street, Triplicane, Madras.

- *Swaminathan, V. S., c/o The Geology Professor, Presidency College, Madras.

T

- *Tadulingam, C., Lawley Road Post, Coimbatore.
- Tambe, S. L., Rao Sahib, B.A., Rural Development Commissioner, Holkar State, Indore, C.I.
- Tamhane, V. A., Government Farm, Sakrand, Dt. Nawabshah, Sind.
- Taylor, John H., Wilson College, Bombay.
- Taylor, Rev. J. T., Indore, Central India.
- *Thadani, K. I., Botanist in Sind, Sakrand, Sind.
- *Thapar, C. S., Department of Zoology, The University, Lucknow.
- *Tiwary, N. K., Hindu University, Benares.
- Trimurti, T. S., Rao Sahib, Professor of Pathology, Medical College, Vizagapatam.
- Trought, Trevor, Lyallpur, Punjab.
- Tumminkatti, M. C., Indian Institute of Science, Hebbal, Bangalore.
- Turkhud, D.A., M.B. C.M. (Edin.), "Iffy," Kodaikanal, South India.

U

- Ubhaya, N. R., Capt., D.P.H., Ag. Director of Public Health, 81, Mount Road, Cathedral P.O., Madras.
- *Ukil, A. C., M.B., 6/1, Kankila Road, Ballygunge, Calcutta.

V

- *Vaidya, B. K., St. John's Vicarage, Tue Brook, Liverpool, England.
- Vaish, Bishambarlal, Professor, Agra College, Agra.
- Vasudevan, A., M.B.B.S., Curator of the Museum, Medical College, Madras.
- Venkataraman, K., M.A. (Hons.), Assistant Paddy Specialist, Government Paddy Breeding Station, Aduturai, Tanjore District.
- Venkataraman, K., Indian Institute of Science, Bangalore.
- Venkataraman, S. N., Assistant to

- the Cotton Specialist, 25, Dobbin Hall, Vepery, Madras.
- *Venkataraman, T. S., Rao Bahadur, B.A., I.A.S., Imperial Sugarcane Station, Coimbatore, S. India.
- *Venkatesachar, B., Professor of Physics, Central College, Bangalore.
- Venkiteswaran, S. P., B.A. (Hons.), 81, Sri Venkiteswara Hostel, Triplicane, Madras.
- Viswanath, B., Govt. Agricultural Chemist, Lawley Road, Coimbatore.
- *Viswanathan, B., Curator, Cass Forest Museum, Lawley Road, Coimbatore.
- Viswanathan, A., Lecturer in Chemistry, Christian College, 4/26, Brodies Road, Mylapore, Madras.
- Volkart Bros., Madras.
- *Vyas, N. D., Agricultural Research Institute, Pusa, Bihar.
- Vydyanathan, M., M.A., I.T., F.S.S. Professor, Pachaiyappa's College, 109, Vellala Street, Purusawalkam, Madras.

W

- Wad, Y. D., Chief Chemical Assistant, Institute of Plant Industry, Indore, C.I.
- Ware, F., Director of Veterinary Services, Triplicane, Madras.
- Washington, I., Community School, Kamalapuram, Cuddapah District, Madras Presidency.
- *Wassodev, Balcrushua V., 3, Warden Road, Bombay.
- *Watson, H. E., Indian Institute of Science, Hebbal, Bangalore.
- *West, Michael, Principal, Teachers' Training College, Dacca.
- *Wright, R. E., Lt.-Col., I.M.S., Shawfield, Egmore, Madras.

Y

- *Yajnik, N. A., Professor of Chemistry, Forman Christian College, Lahore.
- Yodh, B. B., Sandhurst Building, Sandhurst Road, Bombay, 4

ASSOCIATE MEMBERS.

A

- Aiyar, A. Ramachandra, Acting Officer-in-Charge, VI Circle, Civil Veterinary Department, Madura, S. India.
- Aiyar, S. Appaswami, M. A., Professor, Government Victoria College, Palghat, S. India.
- Akhthar, Abdur Rashid, Biological Laboratories, Government College, Lahore.
- Anantakrishnan, S. V., M.A., 81, Sri Venkateswara Hostel, Ice House Road, Triplicane, Madras.
- Anantakrishnan, S. V., B.A., 1, Sri Venkateswara Hostel, Triplicane, Madras.
- Ayyar, A. A. Narayana, Assistant Meteorologist, The Observatory, P. O. Cathedral, Madras.
- Ayyar, K. Narayanaswami, 4, Kariappa Mudali Street, Vepery, Madras.

B

- Badhwar, Rattan Lall, Biological Laboratories, Government College, Lahore.
- Betrabet, Mangesh Venkatrao, Institute of Science, Bangalore.
- Bharadwaja, Y., M.Sc., F.L.S., Hindu University, Benares.
- Bhatia, M. L., Department of Zoology, The University of Lucknow, Lucknow.
- Bonnel, Bonavis, Lecturer in Zoology, Christian College, Madras.
- Bose, N. N., M.A., Lucknow Christian College, Lucknow.

C

- Chakravarti, N., Lecturer in Chemistry, Christian College, Madras.
- Channappayya, H., M.A., Government Museum, Madras.
- Chatterjee, Nirmalapada, M.Sc.,

- 92, Upper Circular Road, Calcutta.
 Chatterjee, B. D., M.Sc., 112, Amherst Street, Calcutta.
 Cherian, M. C., Agricultural Research Institute, Lawley Road, Coimbatore.
 Chetty, C. Ranganayakulu, 20, Govindappa Naik Street, G. T., Madras.
 Chopra, Ram Saran, Biological Laboratories, Government College, Lahore.

D

- Dalal, N. P., D.P.H. (Lond.), Haffkine Institute, Parel, Bombay, 12.
 Daniel, S. G., Madras Educational Service (Retd.), Mission Street, Tanjore.
 Das, Haranam, Department of Chemistry, Government College, Lahore.
 Das-Gupta, N. C., Imperial Dairy Institute, Bangalore.
 Dass, K. S. Gururaja, Lecturer in Chemistry, Central College, Bangalore.
 Dayal, J., Department of Zoology, The University, Lucknow.
 De, Pran Kumar, Indian Institute of Science, Bangalore.
 D'Netto, F., M.B.B.S., 4, Clements Road, Vepery, Madras.
 Devanayaki, Sreemathi N., B.Sc., L.T., 12-A, Park Road, Bangalore.

G

- Gajendragad, N. G., Indian Institute of Science, Hebbal, Bangalore.
 Ganapathi, R., B.A., Department of Agriculture, Quilon, Travancore State.
 Gaugas, T. P., Bazar Jhoo Lal, Lucknow.
 George, C. J., M.A., Ph.D., F.I.C., Agricultural College, Lawley Road, Coimbatore.
 Ghosh, Tejendra Nath, Indian Institute of Science, P.O. Hebbal, Bangalore.
 Ghulatia, Harbans Lall, B.Sc., Biological Laboratories, Government College, Lahore.
 Gogate, D. V., Physics Department, Baroda College, Baroda.

- Gopinath, S. K., Indian Institute of Science, Bangalore.
 Gupta, Babu Lal, M.Sc., Demonstrator, Biology Department, Agra College, Agra.

H

- Hensman, H. S., M.R.C.S., L.R.C.P., M.P.C., Locock's Gardens, Kilpauk, Madras.

I

- Iyengar, H. Ramaswamy, Assistant Professor of Chemistry, Central College, Bangalore.
 Iyer, A. Viswanatha, c/o Imperial Dairy Institute, Bangalore.
 Iyer, B. H., B.Sc., Indian Institute of Science, Bangalore.
 Iyer, K. R. Krishna, H.H. The Maharajah's College of Science, Trivandrum, Travancore, S.I.
 Iyer, N. Krishna, c/o. Imperial Dairy Institute, Bangalore.
 Iyer, P. N. Krishna, Agricultural College, Lawley Road, Coimbatore.
 Iyer, P. V. Seetharama, M.A., King Institute, Guindy, Saidapet Post, Madras.
 Iyer, S. V. Ganapathi, Water Analyst, 10, Gengu Reddi Road, Egmore, Madras.
 Iyer, V. V. Sivarama, M.A., Assistant Professor of Chemistry, Maharajah's College, Ernakulam, Cochin, S.I.

J

- Janniah, Shaha L., Indian Institute of Science, Bangalore.
 Jayaram, G., Veterinary Officer-in-Charge, Maharajah's Veterinary Hospital, Vizianagram.
 Joseph, I., H. H. The Maharajah's College of Science, Trivandrum.
 Joshi, Janakinath, M.Sc., Punjab Agricultural College, Lyallpur, Punjab.
 Joshua, John P., Lecturer in Zoology, Christian College, Madras.

K

- Kane, J. G., Indian Institute of Science, Bangalore.
 Kanhaiyalal, M.Sc., Lecturer, Agra College, Agra.

- Kasinathan, S., Lawley Road, Coimbatore.
 Khubchandani, K. W., Indian Institute of Science, Bangalore.
 Kibble, W. F., Professor of Mathematics, Christian College, Madras.
 Koshy, T. K., H. H. The Maharaja's College of Science, Trivandrum.
 Krishna, B. H., Indian Institute of Science, P. O. Hebbal, Bangalore.
 Krishnamurthy, G. P., Assistant Professor of Physics, Presidency College, Madras.
 Kumarappa, J. M., M.A., Ph.D., Avanashi Road, Coimbatore, S. India.

L

- Lafrenais, H. M., I.M.D., Haffkine Institute, Parel, Bombay.
 Lahiri, M. N., M.B., Public Health Laboratory, Medical College, Patna.
 Lal, Kishen, M.Sc., Officiating Professor of Chemistry, Government College Lahore.
 Lal, Panna, Professor, Science College, P.O. Mahendru, Patna.
 Lorrimer, Mrs. A. P. G., Madras.
 Lowe, Miss Irene H., The Old College, Cathedral P.O., Madras.

M

- Maity, Haripada, Department of Experimental Psychology, 92, Upper Circular Road, Calcutta.
 Majumder, K., The University, Allahabad.
 Malvea, B. B., M.A., M.Sc., Professor of Chemistry, Ewing Christian College, Allahabad.
 Martyn, Joseph, Supervisor, Old Town, Vellore.
 Mayuranathan, P. V., Botanist, Government Museum, Madras.
 Menon, A. S., B.A., M.Sc., Indian Institute of Science, Bangalore.
 Menon, B. K., Indian Institute of Science, Bangalore.
 Menon, K. P., King Institute, Guindy, Madras.
 Menon, Krishna, M.B.B.S., Egmore, Madras.
 Misra, H. P., M.Sc., First Field Assistant Entomologist, Indian Lac Research Institute, P.O. Namkum, Ranchi

- Mistry, S. M., Indian Institute of Science, Bangalore.
 Mitra, Sarat Chandra, 18, Shampooker Street, Shambazar, Calcutta.
 Mohammed, Sardar, Department of Chemistry, Government College, Lahore.
 Mukherji, K. C., 80, Diwan Bazar Road, P.O. Ramna, Dacca.

N

- Narasimham, N. L., Government Arts College, Rajahmundry.
 Narasimhachar, N. Venkata, M.Sc., Assistant Professor of Chemistry, Intermediate College, Mysore.
 Navaneethakrishnan, T. P., Lecturer in Physics, Sri Meenakshi College, Chidambaram.

P

- Pal, B. N., Assistant Chemist, Bengal Tanning Institute, Entally, Calcutta.
 Pandit, S. R., King Institute, Guindy, Madras.
 Paramasivan, S., B.A., B.Sc., Physics Lecturer, Ananda College, Colombo.
 Patwardhan, V. A., Indian Institute of Science, Bangalore.
 Patel, P. Prabhudas, Indian Institute of Science, Bangalore.
 Patel, Sarabhat M. M., Indian Institute of Science, Bangalore.
 Pilley, D. John, Retired Assistant Surgeon, 41, Venkatesa Grammani Street, Chintadripet, Madras.
 Pilley, P. Parameswaren, Indian Institute of Science, Bangalore.
 Pilley, T. R. Narayana, Indian Institute of Science, Bangalore.

R

- Rafay, S. A. c/o Indian Institute of Science, Bangalore.
 Rai, Janiat, Biological Laboratories, Government College, Lahore.
 Rai-Choudhuri, Satyaprasad, 92, Upper Circular Road, Calcutta.
 Rajasekaran, T. K., Lecturer in Mathematics, Christian College, 1/30, Ayalur Muthia Mudali Street, G.T., Madras.

- Ramachandran, M., c/o. Chander's Pharmacy, Mylapore, Madras.
- Ramachandran, S., Chemistry Department, Sri Meenakshi College, Chidambaram.
- Rangachari, T. S., Indian Institute of Science, Hebbal, Bangalore.
- Ranganathan, K. S., L.M.P., King Institute, Guindy, Saidapet, Madras.
- Rangappa, H., Rao Bahadur, 'The Retreat,' Luz, Mylapore, Madras.
- Rao, Bh. S. V. Raghava, c/o. Indian Institute of Science, Hebbal, Bangalore. [Madras.
- Rao, C. P. Rama, M.D., Adyar,
- Rao, D. Ananda, B.Sc., Deputy Director of Agriculture, St. Thomas Mount, Madras.
- Rao, H. S. Madhava, Department of Bio-Chemistry, Indian Institute of Science, Bangalore.
- Rao, Hanumantha, 581, Balakrishna Rao Road, Mysore.
- Rao, Jagannadha, Assistant to the Cotton Specialist, Cotton Breeding Station, Koilpatti, S. India.
- Rao, P. John Sundara, B.A., F.Z.S., Lecturer in Biology, Medical College, Madras.
- Rao, K. Subba, B.Sc., Lecturer in Chemistry, Central College, Bangalore.
- Rao, R. Krishna, B.A., B.L., Advocate, High Court, 4, North Mada Street, Mylapore, Madras.
- Rao, L. Rama, Assistant Professor of Geology, Central College, Bangalore.
- Rao, N. S. Subba, Lecturer in Physics, Christian College, Madras.
- Rao, S. V. Srinivasa, 139, College Road, Mysore.
- Rao, V. N. Ranganatha, Assistant Botanist, P.O. Hiriyr, Chitaldoorg Dt., Mysore State.
- Rao, Y. S. Narayana, King Institute, Guindy, Madras.
- Rau, R. S., King Institute, Guindy, Saidapet, Madras.
- Reddi, T. Sundara, Rao Sahib, Professor of Anatomy, Medical College, Madras.
- Rewadiker, R. S., Indian Institute of Science, Bangalore.
- S
- Sahni, M. R., c/o., Dr. B. Sahni, Botany Department, The University, Lucknow.
- Samuels, Miss Rose, c/o. H. S. Madhava Rao, Esq., Indian Institute of Science, Bangalore.
- Sastri, B. Nanjunda, Indian Institute of Science, Bangalore.
- Sastry, N. S. N., M.A., Psychology Department, Maharajah's College, Mysore.
- Sathe, T. R., Indian Institute of Science, Bangalore.
- Sen, Asok Kumar, M.Sc., University College of Science and Technology, 92, Upper Circular Road, Calcutta.
- Seshadrinathan, N., Captain, M.B. B S., Mylapore, Madras.
- Sewell, Mrs. R. B. S., Indian Museum, Calcutta.
- Shenai, K. K., Hygiene Laboratory, Medical College, Madras.
- Shrinivas, Nargund Krishna, Gujarat College, Ahmedabad.
- Shroff, T. R., Indian Institute of Science, Bangalore.
- Singh, Gopal, Biological Laboratories, Government College, Lahore.
- Singh, N. K., Professor, Agra College, Gokulpura, Agra.
- Srikantan, B. S., Indian Institute of Science, Hebbal, Bangalore.
- Subramaniam, R., L.M.S., B.S.Sc., Propaganda Officer, Public Health Department, 99, Linga Chetty Street, G. T., Madras.
- Subramaniam, R. V., Nili Veeraswami Chetty Street, Triplicane, Madras.
- Sud, S. R., M.Sc., Lecturer, Agra College, Agra.
- Sukhtankar, V. A., Director, State Education, Indore
- Sundaram, P. S., c/o. Indian Institute of Science, Bangalore.
- Suryanarayana, M., Lawley Road P.O., Coimbatore.
- Sutaria, R. N., Department of Biology, Gujarat College, Ahmedabad.
- Swaminathan, S., Professor of Anatomy, Medical College, Vizagapatam, (118, China Bazar Road, Madras).
- T
- Theodore, J. H., King Institute, Guindy, Saidapet, Madras.
- Timothy, B., King Institute, Guindy, Saidapet, Madras.

V

- Valoeker, R. K., Royal Institute of Science, Bombay.
 Varadhan, C., "The Crags", Seshadripuram, Bangalore.
 Vareed, C., M.B.B.S., Demonstrator of Pharmacology, Medical College, Madras.
 Venkatachari, T. E., B.A., Demonstrator, Chemistry Department, Presidency College, Madras.
 Venkataraman, Mrs. K. c o. Dr K. Venkataraman, Indian Institute of Science, Bangalore.

- Venkataraman, K. V., King's Institute, Guindy, Saidapet, Madras.
 Venugopalan, M., Indian Lac Research Institute, Namkum, Ranchi.
 Viswanathan, G. R., Veterinary College, Madras.
 Viswanathan, K. S., Hygiene Laboratory, Medical College, Madras.

Y

- Yoganandam, G., A.I.I.Sc., Indian Institute of Science, Hebbal, Bangalore.

STUDENT MEMBERS.

A

- Agrawala, K. S.
 Ammal, Miss M. Kalyani.
 Anantachari, T. A. P.

B

- Balasubrahmanian, T. R.

C

- Chatterjee, S. C.
 Cherian, A. J.

D

- Das, Khagendranath.
 David, Miss M.

G

- Gopinath, Mrs. S. K.

H

- Hasan, M.

I

- Iyer, C. R. Harihara.

J

- Joseph, K. J.

K

- Kanakaraju, T.
 Kanthamani, Miss D.
 Kapil, B. R.
 Krishnamurthi, C. E.
 Krishnaswami, R.
 Kuppaswami, B.

M

- Mathur, C. B.
 Menon, K. S.
 Menon, M. G. K.
 Menon, P. K.
 Middleton, W. E.
 Mitra, Birendrakumar.
 Mukherjee, L. N.
 Murthi, M. L. N.

N

- Narayanaswami, M. R.

P

- Padmavati, Miss A. S.
 Paramasivan, C. V.
 Pooviah, Miss A.
 Puttananjappa, B. R.

R

- Rachel, Miss John.
 Rajagopal, M. A.
 Ramachandran, K. R.
 Ramachandran, N. S.
 Ramappayya, H.
 Ramiah, P. M.
 Ranganathan, S.
 Rao, C. K. Vasudeva.
 Rao, K. G. Rama.
 Rao, C. V. Rama.
 Ratnam, R.
 Rattan, Basant.
 Rau, S. Ananda.

S

- Sambasivan, R.
 Samuel, Miss M. P.

Santhasunthari, D.
Saran, Ram.
Sarma, P. Balakrishna.
Sarma, S. Ramachandra.
Sati, Miss O.
Seetharam, Mrs. Kalyanasundari.
Shukla, S. N.
Siddappa, G. S.
Singh, Hazara.
Solanki, Miss Margaret J.
Srinivasachari, N.
Subbarathnam, P. G.
Subbiah, M. G.
Subrahmanyam, P. R.
Sundararajan, R.

T

Tandon, H. L.
Trikamlal, Bhatt. Chinubhai.

U

Uttaman, M.

V

Varadarajan, S.
Venkatakrishniah, B.
Venkatachari, T. R.
Venkataraman, S. S.
Venkataraman, T. S.
Venkataraman, T. V.
Venkatesachar, V.
Verghese, Miss M. R.
Vimala, Miss S.
Vivekanandam, A. K.

RULES.

INDIAN SCIENCE CONGRESS.

I. The administrative work of the Congress shall be carried on by an Executive Committee, who shall submit such questions as they think desirable to a General Committee at its annual meeting or at a special meeting of which satisfactory notice shall be given.

II. The General Committee shall consist of all full members (*Vide Rule XI*;) who have attended three meetings (including that actually taking place at any time) and those members who have held office in the Congress. This Committee shall meet at least once at each Congress, usually in the middle of the meeting.

III. The Executive Committee shall consist of the President, the retiring President, the two General Secretaries, the Treasurer of the Asiatic Society of Bengal, the General Secretary of the Asiatic Society of Bengal and three members elected by the General Committee at its Annual General Meeting. The Executive Committee shall have full powers to transact all business in case of need, notwithstanding any limitations herein laid down.

IV. The Council shall consist of the members of Executive Committee, of the Past Presidents resident in India and five other members appointed by the General Committee at its annual meeting.

The Council shall be consulted on matters of general scientific importance and policy.

V. The nomination of the President shall be made by the Executive Committee and submitted for confirmation to the General Committee.

VI. The Sectional Presidents shall be appointed by the Executive Committee.

(*Experience shows that there is not time for any other arrangement to work satisfactorily.*)

VII. The two General Secretaries shall be nominated by the Executive Committee and submitted to the General Committee for confirmation.

¹ Each General Secretary shall hold office for five years from the date of his appointment, but shall be eligible for reappointment.

VIII. As long as the present relationship with the Asiatic Society of Bengal continues, the General Secretary and the Treasurer of that Society shall be members of the Executive Committee.

IX. The Local Secretary (or Secretaries) and the Local Committee for any meeting of the Congress shall be appointed by the Executive Committee.

X. The Local Secretary (or Secretaries) and the Local Committee shall assist in making arrangements for the reception and entertainment of the visitors and for the distribution of letters at the meeting.

XI. There shall be three classes of members:—

(i) *Full members* : Annual subscription *Rupees ten.*

(ii) *Associate members* : Annual subscription *Rupees five.*

(iii) *Student members* : Annual subscription *Rupees two.*

(Student members must be definitely certified by the principal of their College as *bona fide* students.)

¹ Added at the Calcutta Meeting, 1928.

Only full members have the right of communicating papers to the Congress and they receive free of charge all publications. Associate and Student members have the right of reading papers before the Congress provided they have been communicated by a full member.

¹ XII. The following procedure is to be adopted for making any additions or alterations in the above rules:—

(a) Proposals for additions to and alterations in the existing rules are to be sent to the General Secretary at least two months before the meeting of the General Committee at which they are to be moved. The General Secretary, on receipt of such proposals, shall circulate them to all members of the General Committee who paid their annual subscription at the last session of the Congress.

(b) Any amendments to the proposals shall be sent to the General Secretary at least a fortnight before the meeting of the General Committee.

¹ XIII. The proposals with amendments shall be brought up before the meeting of the General Committee (with remarks of the Executive Committee, if any) and declared carried, if accepted by a two-thirds majority of those present at the meeting.

SECTIONAL COMMITTEES.

XIV. (a) The Sectional Committees shall consist of not more than three members who shall be:—

- (1) The President of the Section (Convener).
- (2) The retiring President of the Section.
- (3) One member elected by the General Committee at its Annual General Meeting.

(b) The Sectional Committee shall arrange and referee all papers to be read before the Section.

(c) The Sectional Committee shall have power to fill vacancies during the year of their appointment.

(d) The Sectional Committee shall nominate annually a President for the Section for the consideration of the Executive Committee.

PAPERS.

² XV. (a) An abstract of any paper to be read at the Indian Science Congress must be submitted to the General Secretary or the President of the Section concerned not later than the 15th of October. [This will enable abstracts to be printed and circulated to members before leaving their Stations to attend the Congress.]

(b) All papers which are to be read must be refereed by the Sectional Committee or by some person appointed by them, the decision to be final and all reports confidential. In deciding whether a paper should be read the Sectional Committees will take into consideration the question whether the paper has been previously published.

(c) Each paper must be accompanied by an abstract and if the paper be of great length, it should be summarised.

¹ Added at the Bangalore Meeting, 1924.

² Amended at the Benares Meeting, 1925.

ACCOUNTS.

I.

*Account of the Indian Science Congress for the year ending
the 31st December, 1928.*

EXPENDITURE.				RECEIPTS.			
Dr.				Cr.			
		Rs.	A. P.			Rs.	A. P.
By printing	..	3,674	4 3	To balance	..	16,525	10 2
„ Advance	..	100	0 0	„ Contribution,			
„ Salaries	..	600	0 0	Indian Institute			
„ Postage	..	290	8 6	of Science,			
„ Stationery	..	65	8 0	Bangalore	..	300	0 0
„ Contingencies	..	22	0 0	„ Contribution,			
„ Balance	..	17,845	15 5	A.S.B.	..	250	0 0
				„ Interest on Fixed			
				Deposit	..	175	0 0
				„ Subscriptions	..	5,347	10 0
TOTAL Rs.	..	22,598	4 2	TOTAL Rs.	..	22,598	4 2

*Sd. BAINI PRASHAD,
Honorary Treasurer,
Asiatic Society of Bengal.*

II.

INDIAN SCIENCE CONGRESS, SESSION, 1929, MADRAS.

Statement of Local Accounts.

Receipts and Payments account.

TO RECEIPTS.			BY PAYMENTS.		
	Rs.	A. P.		Rs.	A. P.
Government grant ..	2,500	0 0	Stationery and print- ing ..	599	8 9
University grant ..	2,500	0 0	Guide Books ..	1,010	8 0
Corporation grant ..	500	0 0	Postage and tele- grams ..	107	3 0
Sir S. R. M. Anna- malai Chetty ..	500	0 0	Garden and Dinner Party ..	3,531	1 0
Sundries ..	728	0 0	Labour charges ..	214	0 0
Donations for Dinner Party ..	1,125	0 0	Bus and Lorry ex- penses ..	866	10 6
Sale of Membership tickets ..	2,430	0 0	Rents including tent- age ..	660	9 3
Subscriptions for Dinner Party ..	290	0 0	Furniture hire ..	460	3 0
Sale of excursion and lunch tickets ..	654	8 0	Electric charges ..	288	14 0
Stall accommodation fee for exhibition ..	150	0 0	Photo charges ..	37	0 0
Sale of Guide Books ..	24	6 0	Establishment ..	298	12 0
Reservation charges for accommodation ..	24	0 0	Typewriter hire ..	150	0 0
Bank interest up to 31-12-1928 ..	26	5 1	Remittances to Cal- cutta ..	2,363	0 0
Cheque drawn but not cashed ..	37	8 0	Miscellaneous ..	275	10 0
			Cash on hand ..	48	11 6
			„ with the Bank ..	578	0 1
TOTAL Rs. ..	11,489	11 1	TOTAL Rs. ..	11,489	11 1

I have checked the cash book and examined the vouchers, compared the Bank Pass Book and have obtained all the necessary information and I certify that the above cash abstract is correct.

Sd. M. K. DANDEKAR,
B.A., F.S.A.A., (Hon.)

Incorporated Accountant.

MADRAS,
The 4th March, 1929.

K. G. PANDALAI, MAJOR, I.M.S.,

A. F. MacCULLOCH, M.A., B.Sc.,

Local Secretaries,

16th Indian Science Congress.

Note.—Subsequent payments and petty expenses as per letter dated 15th March 1929 from Major K. G. Pandalai, I.M.S.

	Rs.	A.	P.
To Sundries	126	11	7
Net balance of Rs. 500 made over to the Treas- urer, Indian Science Congress, Calcutta ..	500	0	0
	626	11	7

